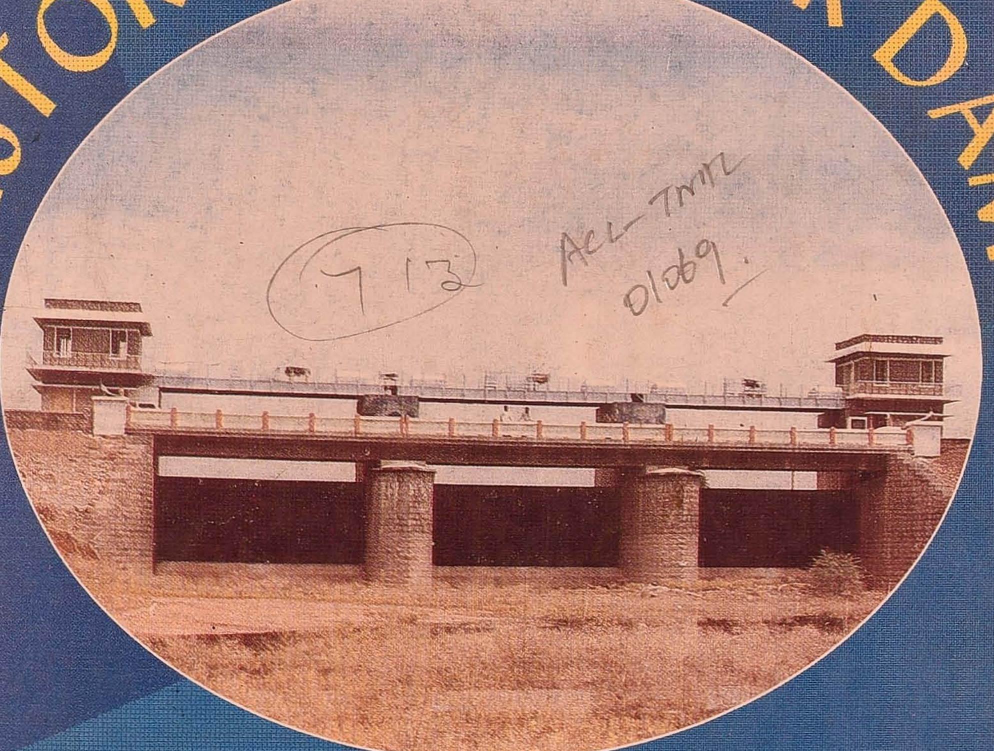
GOVERNMENT OF TAMILNADU
WATER RESOURCES ORGANISATION
PUBLIC WORKS DEPARTMENT

HISTORY OF VANIAR DAM



COMPILED BY Er. S. THIAGARAJAN
Chief Engineer, WRO/PWD (Retd.)

D27.2116.v'N85
N95.
227981.

DAM SAFETY DIRECTORATE,
CHEPAUK, CHENNAI - 5

15 பிப் 1999

GOVERNMENT OF TAMILNADU
PUBLIC WORKS DEPARTMENT

WATER RESOURCES ORGANISATION

HISTORY OF VANIAR DAM

Compiled by

S.Thiagarajan B.E.F.I.V.
OSD (Chief Engineer), WRO - PWD (Retd.)

Dam Safety Directorate,
Chepaukkam, Chennai - 5.

FOREWARD

The Dam Safety Project externally aided by World Bank contemplates many activities for safety of Dams and updating the Records relating to the various irrigation projects in the Tamilnadu State.

One of the aims is to write and preserve the History of Dams. As the writing of history of project involves expertise knowledge of the various aspects of execution of dam, the task of writing history was entrusted to the Retired Engineers of Public Works Department and the Government of Tamilnadu have also approved the proposals to utilise the services of the Retired Engineers for compiling the History of Dams.

The Vaniar Dam is one among and the task of writing History was assigned to **Er.S.Thiagarajan, Retired Chief Engineer,** P.W.D.

Er.S.Thiagarajan with his vast experience in the field of irrigation project and wide knowledge in the irrigation system has brought out this volume of **"HISTORY OF VANIAR DAM"** with his best efforts.

This publication contains the General History from the formulation to completion, earth dam, masonry dam and appurtenant works, history of dam since commissioning.

I acknowledge the excellent effort putforth by **Er.S.Thiagarajan** in bringing out the **"HISTORY OF VANIAR DAM"** in a most comprehensive manner, making it a very valuable contribution to the Engineering field.

Superintending Engineer,
Dam Safety Directorate, WRO/PWD
Chennai - 600 005.

HISTORY OF VANIAR DAM

PREFACE

IRRIGATION IN THE PRE-INDEPENDENT INDIA - AN OVERVIEW

It was Shri Jawaharlal Nehru, the most distinguished and illustrious Prime Minister of India who called the irrigation dams as "The Modern Temples of the Nation". It is appropriate to have so described them; while the places of worship enrich the spiritual life of the people, the storage systems provide for the material well-being of the masses. This exalted position of the water control arrangements was well recognised by the ancient rulers and poets of our land. The Tamil epic "Purannaanooru" composed 2000 years ago imparted the following advice to the Kings "If you want to establish your reputation among your people Store great quantities of water in the valleys of your Kingdom. Those who failed to store water will fail to store their glory". Accordingly the Monarchs gave primary attention to the formation and maintenance of the storage works. While rulers took the initiative of initial investigation and construction of these works, the responsibility for their maintenance was generally assumed by the communities. A number of irrigation tanks were built. Many of them were rainfed and a few were supplied by channels taking off from rivers through open off-takes and Kutcha diversion and head up arrangements.

During the British Colonial Rule, a major change took place. A number of pucca diversion structures - with canals and regulating arrangements were constructed for irrigation either directly or through tanks. Also the ownership of land and water was taken away from the communities and vested in the Government either directly or through Zamindari system. Further, the schemes were sanctioned and executed largely with commercial interests in mind. Except during acute famines, the alien power preferred not to implement projects which did not meet stringent economic criteria.

POST-INDEPENDENCE DEVELOPMENTS IN TAMILNADU IRRIGATION SECTOR - A PROFILE

After independence in 1947, the trend took a positive turn and many new reservoirs for irrigation and power were built and operated even though they worked out to be economically less viable. Tamilnadu had its share in these post - independence developments. Quite many new schemes were implemented during the several Five Year Plans formulated after 1947.

Irrigation in Tamilnadu has a history dating as far back as 04th millennium B.C. Many old irrigation works bear testimony to the developed techniques of which Kallanai (Grand Anicut) stands upper most. This is a solid work of masonry built on sandy bed. Erstwhile Madras Presidency has a water potential of 6,000 TMC (1,69,920 Million m^3). The All India Water Resources per capita is 0.09 M.Cft. that of Tamilnadu is only 0.026 m.cft. Our neighbours Karnataka and Kerala are much better in this regard at 0.11 and 0.12 m.cft. per capita respectively. We are only next to Rajasthan in this respect, but Rajasthan recently got the benefit of handsome diversion of water from Bakranangal.

The area shown in Tamilnadu is 6.2 million hectares - out of a total geographical area of 13.2 million ha. - out of which about 3 million ha. only had irrigation facilities through canals, tanks and wells, prior to independence. The river and canal system accounted for 1.1 million ha. 0.90 million ha. get irrigated through tanks and the rest by wells, rains and spring channels. We were able to add 0.36 million ha. through the plan periods. This was achieved through a number of major and medium plan projects and building as many as 39 dams big and small and excavating the canal systems incurring an expenditure of Rs.3662.5 million.

Ground water prospects of the State is not bright. Much of the area being rocky (grey), the recharging in poor. The yield depends on the intensity of monsoonic rains. Ground water storage does not last long. There are 71,895 tubewells and 16,77,185 dug wells used for irrigation. Out of which 11,84,450 have been energised. This accounts for the largest member of energised wells in the country.

PRESERVATION AND SAFETY MEASURES

Total surface water utilised in Tamilnadu is around 96% of total surface water-potential of the State. Hence in the eighties attention was focussed on derivation of larger benefits from the irrigation potential so far created. Improvements to the canal distribution systems became the prime concern. The stability and durability of the Head Works on which the distribution networks depend assumed importance in this context. The necessity for an organisation which will be exclusively concerned with all the safety aspects of all the major, medium and minor irrigation dams in the State became apparent. As a result the Dam Safety Directorate in PWD under the control of a Director was set up by virtue of the Government order No.725 PWD dated 18th April, 1991.

Among the directorate's earliest responsibilities were the rehabilitation of dams in distress. The upgradation measures were to be identified and finally decided through safety inspections and studies by a multi-disciplinary team. In the process it came to be known that a complete recorded history of many dams taken up after independence was not available. The Central Water Commission of the Government of India through its meetings as National Committees on dam safety was highlighting the desirability of having History Report for every completed project. Generally a past history is a basis for shaping a better future. A detailed record of the concepts, investigations, formulations examination of alternatives which precede the design and construction of a reservoir project and also the events and activities during its implementation stage including the problems met with and modifications made will be a most welcome document for those who wish to add to their knowledge of dam building techniques besides serving as an useful reference for studies undertaken for safety evaluations of its various components.

In this background, the Government was approached by the Chief Engineer, PWD (Irrigation) to accord permission to get history reports in respect of 8 (eight) dams prepared by engaging retired senior engineers of the Department who were associated with the formulation and implementation of some of the reservoir projects in the State while in service. A panel of names was also suggested. The Government approved the proposal in G.O.Ms.No.237 dated 25.03.95. The undersigned was one among the panel and the writing of the History of Vaniar Dam was assigned to him.

Details for compiling the History Report were obtained from the old records and files relating to the subject which were available in the Offices of the Superintending Engineer, PWD, Special Projects Circle, Krishnagiri, Section Officer, PWD, Harur, Superintending Engineer, PWD, Salem Dharmapuri Circle. Salem, Office of the Superintending Engineer, PWD Designs Chepauk, Madras and the Chief Engineer Irrigation Madras. Discussion were held with the personnel who were involved in the construction of the project for information on important events and changes made during the implementation stage. Based on the details so ascertained the report is drafted and presented in 4 (four) parts as per terms of reference as mentioned below:

Part I	:	Covers the objectives of the Project and Contains all details from formulation, land acquisition and completion of preliminaries.
Part II	:	Deals with details about the formation of earth dam including machinery used and field tests.
Part III	:	Includes all aspects from foundation to completion of all the dam appurtenant works including gate erection and instrumentation.
Part IV	;	Gives an account of the developments after commissioning of the project including protection of environment and ecology and staffing.

Acknowledgments

The writer is much grateful to the following officers of the Department for the co-operation extended and assistance rendered in making available the required references, files, documents, records and drawing etc. to draft the various chapters. But for their kind help, the task would not have been completed satisfactorily. The writer is much obliged to them and wishes them all well.

1.	Thiru.M.K.Natarajan	Chief Engineer Retd. (who was Executive Engineer Incharge of the Head works for over 4 years)
2.	Thiru.S.Shanmugam	Superintending Engineer, PWD Projects Circle, Krishnagiri, till 31.3.96.
3.	Thiru.K.Annaraja	Superintending Engineer, PWD Project Circle after 18.5.96.
4.	Thiru.Velayutham	Executive Engineer, PWD., Dharmapuri Divn.
5.	Thiru.T.Paramasivam	Junior Engineer, PWD Harur Section
6.	Thiru.S.Shanmugam	Draughting Officer PWD Special Projects Circle, Krishnagiri
7.	Thiru.D.Chengalvarayan	Chief Engineer and Director Institute of Water Studies, Taramani.

8.	Thiru.K.Natarajan	Deputy Chief Engineer, PWD Design Circle Chepauk, Madras.
9.	Thiru.T.Krishnaswamy	Chief Engineer, PWD, Operation & Maintenance, WRO, Chepauk, Madras.
10.	Thiru.S.R.Raghavan	Deputy Chief Engineer Retd. ISW, Chepauk, Madras.
11.	Thiru.V.Sukumar	Assistant Executive Engineer Office of the Chief Engineer O & M, Madras
12.	Thiru.M.Viswanathan	Director, PWD Retd. Dam Safety Directorate, Madras
13.	Thiru.A. Dhanagar	Executive Engineer Dam Safety Directorate, Madras.
14.	Thiru.P.S.Thiagarajan	Junior Engineer, Dam Safety Directorate.

CONTENTS

Titles *Page No.*

1. FOREWORD I

PREFACE ..... II-V
Irrigation in Pre-independent India
Post Independence Developments in Irrigation,
Tamilnadu - A Profile
Preservation and Safety Measures
Acknowledgments

2. INTRODUCTION (SYNOPSIS) 1-3
Early History
Formulation and Implementation of the scheme

PART I

3. CHAPTER 1 4-7
Objectives
Benefits contemplated
General Information

4. CHAPTER 2 8-14
Preliminary investigation and proposal
Earlier schemes and their fate
Alternatives investigated
Decision on the location of the scheme

5. CHAPTER 3 15-16
Correspondence relating to the
Formulation of the Scheme

6. CHAPTER 4 17-18
Detailed Investigations
Preliminary Estimates and Consideration.
Design Circle's Findings

7. CHAPTER 5 19-23
Hydrology
Features of The Parent River
Hydrometeorology
Characteristics of Vaniar Sub-basin
Yield and Flood Discharge Calculations.

8. CHAPTER 6 24-33
Geological studies in and around Vaniar basin
Geological Features
Hydro-Geology
General Geology of Vaniar Command

Titles *Page No.*

9. **CHAPTER 7** **34-36**
   Sanction Accorded by Government
   Government Order
   Programme of work outlined

10. **CHAPTER 8** **37-41**
   Land Acquisition
   General
   Requirements Exceeded
   Revenue Officers Assigned. Procedures
   Explained
   Tackling Difficult cases

11. **CHAPTER 9** **42-45**
   Transfer of forest Land
   Surplus Lands

12. **CHAPTER 10** **46-48**
   Access road campus buildings and lay out
   Officers who were in charge of and
   Associated with Vaniar Project

LIST OF ANNEXURES

1. Inflows And Out-Flows Statement (Projections) 49
2. Benefit-Cost Ratio Calculations. 50
3. Test Results (Correspondence & Statements) 54
4. Dist Agricultural Officer's Letter on the suitability of soils in Vaniar Ayacut. 62
5. Copy of Chief Engineer (Irrigation) Letter returning the plans and estimates with remarks to Supt'g. Eng'r. Investigation Circle, Trichy. Dt.20.07.77. 63
6. Executive Engineer's Letter, dt.06.09.77 resubmitting the above Plans & Estimates after attending the remarks. 65
7. Vaniar Scheme Estimates; Classified abstracts For Head Works and Canals. 68
8. Copy of G.O.Ms.No.994 Forest & Fisheries Dept. ordering transfer of Forest Lands to P.W.D. 77
9. Descriptive Note on Problems and bottlenecks in taking over of forest lands by Sup'g. Eng'r. Project Circle, Krishnagiri. 80
10. Vaniar Reservoir Project: Model Studies Report to finalise Surplus Course, Drops and Trough Aqeduct. (By Institute of Hydraulics and Hydrology, Poondi) 86

PART II

13. **CHAPTER 11** 93-97
Preliminaries and Site Clearance Works
Clearances done in Various Stages
Ceremonious Start of the Work
High Bids and Lack of Response
Ceiling Rates - Procedures
Site Clearance Works Specifications Adopted

14. **CHAPTER 12** 98-100
Protection Works - River Diversion, Coffer Dams, Etc.
Planning the Diversions
General and Tunnel Diversion
Arrangements made in Vaniar Site

15. **CHAPTER 13** 101-121
Formation of Earth Dam
General Features
Estimate Provisions
Design Considerations
Works Started Prior to Technical Sanction
Construction of Earth Dam
Restrictions in the Depth of Cut-off Trench
Tackling the River Course Portion for the Cut-off Trench
Forming Zones Filter, Rock Toe and Toe Drain
Hillock in the Alignment - difficulties Encountered
Agency for the Formation of the Earth Dam
Borrow Areas for Different Soils - Fixed
Uniform Consolidation - Extra Width of Shell Zone
Clay Blanket in the River bed Portion
Filter Rock Toe in the River Course - River Side
Jeddy Stone Revetment
Parapet and Road on Top of Dam

16. **CHAPTER 14** 122-124
Departmental Supply of Explosives
Background
Licence to Deal in Explosives - Magazine Stores
Procurement of Small quantities by Contractor

17. **CHAPTER 15** 125-129
Articles of Interest Found During Excavation
Articles of Interest and Veneration
Stages of Progress and Slippages

LIST OF ANNEXURES

1. Vaniar Scheme Design Sheets for Earth Dam Zoned Section and Filter 130-138

2. Vaniar Scheme Earth Dam Earth Quake Analysis 139

3. Proposal of Executive Engineer for Splitting up of work of forming Filter and rock toe between 620 m and 750 M 142

4. Government Approval for the above proposal 143

5. Vaniar Reservoir Scheme - Earth dam Typical Section 144

Titles *Page No.*

PART III

18. CHAPTER 16 145-146
Components of the Dam
Foreword
Temporary Reference Bench Marks

19. CHAPTER 17 147-152
Specifications
For Water
Water and Concrete
Masonry Random Rubble for Hearting
Masonry Face Work
Lead for Materials
Quality Control

20. CHAPTER 18 153-159
Surplus Regulator
General Description and Necessity
Design of the Regulator
Preparation of Plans and Estimates
Orders on Tenders
Division of Works
Problem in Usage of Sand
Location of Regulator Shifted
Concreting Methods - Sequence of Works
Bed Blocks - Design and
Construction Details

21. CHAPTER 19 160-165
Surplus Course
General Description - Model Studies
Extra Rate for Earth Works
Drops in the Surplus Course
Leads, Lifts Ramps etc.

22. CHAPTER 20 166-168
Tower Head Sluices
Designs, Revised and Adopted
Construction Stages
Work Delays

Titles *Page No.*

23. **CHAPTER 21** **169-170**
    Saddle Anicut
    Location Fixed
    General Cost Escalations and
    Attempts to Cut Down the Costs
    Expenditure Incurred
    Suspension of Work

24. **CHAPTER 22** **171-173**
    Erection of Gate Hoisting Equipment
    General Responsibility
    Specific Requirements and Accessories
    Hoisting Equipment

25. **CHAPTER 23** **174-186**
    Vaniar Project Canals
    Organisation and Programme
    Ayacut and Alignment
    Main and Branch Canal Design
    - Basic Principles
    Casting Yards for Pre-cast Slabs
    - Casting Procedures
    Specifications for Linings
    Mode of Execution
    Cut and Cover
    Cross Masonry Works - Construction of
    Grouping of Ayacut
    Actual Expenses for Canal System

LIST OF ANNEXURES

1. Copy of Design for Surplus Regulator **187-231**
2. Copy of Design of Surplus Course and Drops **232-247**
3. Copy of Design of Drops in Surplus Course **248-255**
4. Copy of Design of Approach Bridge for Irrigation Sluices **256-266**

PART IV

26. **CHAPTER 24** 267-287

Commissioning and Maintenance
Distribution System
Cultivation Statistics
Existing Condition of Infrastructure
Flood Damages
Operating Procedures
Review of Deficiencies
Inflows and Outflows Recorded
Farmers' Involvement
Fisheries Activities in the Vaniar Reservoir
Improvements etc. Contemplated under WRCP
Conjunctive Water Use Plan

27. **CHAPTER 25** 288-290

Environmental Aspects
General Awareness and Appreciation
Resettlements
Aeshthetic Effects
Effect of Changed Landuse
Reservoir Storage Impacts

28. **CHAPTER 26** 291-294

Maximum Flood Considerations
PMF-SPF Values - Remarks
Actual Flood Encountered

29. **CHAPTER 27** 295-301

Maintenance Aspects and Staffing
Status of Irrigation Development
Status of Participatory Management
Cost of Upkeep
Current Operation and Maintenance Management
Organisation Chart
Maintenance Budget
List of Equipment
Communications etc.

Titles *Page No.*

LIST OF ANNEXURES

1. Vaniar Rervoir System Land Use Pattern 302

2. Cross Masonry Structues in the Right and Left 303-320
Main Canals of Vaniar Reservoir Project

INTRODUCTION (SYNOPSIS)

I. EARLY HISTORY AND DEVELOPMENTS

1.1. The history of Vaniar Dam spans over a period of nearly 120 years. A reservoir across Vaniar which is a tributary to the river Ponniyar was conceived as early as 1877 by Mr.Lofanna, I.C.S. who was the then Collector of Salem District; And the scheme came into operation in March,1985 when its waters were first released for a portion of its ayacut. Finishing items and improvements mostly on the distribution system continued. The expenditure till February, 1992 was Rs.1114.85 lakhs. While the proposals framed during British Regime did not fructify due to an unknown apathy of the alien rulers towards large scale expenditure for community welfare those investigated after independence had to await sanction till 1979 in view of priorities for other schemes in the Ponnaiyar basin. The long wait however, resulted in an environmental friendly project. For, the Vaniar scheme was not only scientifically planned, it stands justified economically and socially including values like distributive justice.

1.2. During the period from 1877 to 1897, 3 (three) schemes were investigated by English Executive Engineers. The capacities contemplated during these earliest attempts ranged from 324 million cubic feet (M.cft) (9.17 Mm^3) to 297 M.cft. (8.41 Mm^3) to irrigate 3,000 acres, 6,000 acres and 10,500 acres. All these proposals were found unworkable by Mr.M.Oconnel, the Superintendent Engineering in 1887. The objections recorded for shelving the schemes are dealt with in Chapter 2.

1.3. Conceding to the persistent demand of the well meaning farmers of this area for irrigation facilities, the Government in the year 1906 instructed Thiru Arokyasami Mudaliar, Executive Engineer, Salem-Coimbatore Investigation Party to come up with viable alternative to satisfy their requirements. He framed a scheme to put up a reservoir just below the confluence of the sub-tributary Kallar (alias Thurijahalli River) with this major tributary two miles west of Harur. This scheme was rather ambitious. It contemplated capacities as high as 1133 M.cft (32.88 Mm^3) at FRL 767 ft. and 2456 M.Cft. (69.54 Mm^3) at FRL 780 ft. It was projected that about 25,600 (10364 ha.) acres would get benefited. This proposal involved submersion of considerable extent of ayacut already under cultivation and would render 2 (two) miles stretch of an important State Highway (the Salem-Thiruppattur Road) out of use due to submersion. It was also expected that it would adversely affect the irrigation interests of Thirukoilur Anicut system. Hence further investigation of schemes for harnessing Vaniar waters was deferred.

1.4. The farmers of the area were not however, disheartened. They were approaching the authorities every now and then and kept up their demands alive. The attitude and outlook of the District Administration and the policy of Government during the British Rule till 1947 were different. The economic criteria for sanction of projects designed to benefit native masses in those days was stringent. It may be of interest in this context to quote the following extracts from The Discovery of India by our most illustrious former Prime Minister of India Shri Pandit Jawaharlal Nehru. One remarkable contradiction meets us at every turn in

considering the record of British Rule in India. The British became dominant in India and foremost power in the World because they were the heralds of the new big machine industrial civilization. They represented a new economic force which was going to change the world and were thus, unknown to themselves, the fore runners and representatives of change and revolutions, yet they deliberately tried to prevent change except in so far as this was necessary to consolidate their position and help them in exploiting the country and their people to their own advantage. Their outlook and objectives were reactionary, partly because of the background of the social class that came here but chiefly because of the deliberate desire to check change in a progressive direction as these might strengthen the Indian people and thus ultimately weaken the British hold on India.

After Independence in August 1947, the trend took a positive turn when priority was assigned to irrigation under grow more food programme. The special sub-division formed at Krishnagiri on 23rd August, 1948 was entrusted with the task of framing proposals for a dam at a suitable place across Vaniar.

FORMULATION AND IMPLEMENTATION OF THE SCHEME

1.5 The special staff took up investigations for forming reservoir in the Upper reaches of the river Vaniar at two places -one was near Harur and the other a little away from Pappireddipatti. These proposals were examined in the light of water balance for the whole of Pennaiyar River besides other standards of evaluation. With the limited data available that time, a definite picture about surplus after meeting all the lower down irrigation in the parent river, like Thirukoilur and Sornavur Anicut systems could not emerge. The enterprising farmers of the area had to wait till the completion of Sathanur and Krishnagiri reservoir projects for which claims had been put up earlier and for which the claimants and benefits were of larger magnitude than those for a scheme across the tributary Vaniar.

1.6 The hydrology of the Pennaiyar basin was once again examined after the operation of Krishnagiri and Sathanur Projects during the years 1967 to 1971. It was established that surplus yield of the order of 6.5 T.M.Cft. (184 Mm^3) was available after meeting the then riparian interests in the river basin. Detailed investigation of the proposal was carried out in the years 1976 and 1977. The location of the dam was decided taking in to account the availability of sound foundation rock at shallow depths and the strong plea of the people of Mullikadu Village to avert submersion of a good portion of their own fertile lands. Approval was finally accorded in G.O.M.S.No.284 PWD dt.20th February, 1979 for forming a reservoir of capacity 434 M.cft. at an estimated cost of Rs.560 lakhs based on 1978-79 rates. The schemes benefits a new extent of 3,462 ha. (8.550 acres) dry ayacut besides stabilising 750 ha. (1,852 acres) of wet lands.

1.7 The special Projects Circle at Krishnagiri which was newly created and functioning since 1979 was entrusted with the execution of the work. Vaniar Headworks Division-I was formed on 06th June, 1979. A second Division to deal exclusively with canal distribution and ayacut localisation works started functioning from April,. 1980. The scheme was inaugurated on 3rd March, 1985 at an impressive ceremony at the Dam Site by the then Hon'ble Minister for works

(PWD) (Thiru Mohammed Yusuf.) The Canals were thrown open for irrigation in the head reaches on the same day.

1.8 The history of Vaniar Dam is presented in 4 (four) sections. The section I deals with the various stages of Project from its inception (formulation) to land acquisition and completion of campus and layout roads. The Chapters under Sections II & III cover formation of earth dam construction of masonry dam and all appurtenant works including erection of gates and distribution (canal) system. The problems encountered during the commissioning and operation stages, the improvements and modifications carried out after original constructions and a note on ecology and environment are included in the last (4th) section.

CHAPTER 1
OBJECTIVES

1.1 The territorial extent of Dharmapuri District is 9.63 lakhs hectares, out of which cultivable lands were identified to be about 35 percent only. The area which received irrigation was 54,000 ha. only when the district was originally carved out of Salem District in 1964. It worked out to be less than 6 percent of the total geographical area of this new and backward district. The need to augment its irrigation potential was therefore paramount. The first choice in this context before the authorities was Vaniar Project for which the demand was long standing and persistent.

BENEFITS CONTEMPLATED

1.2 Primarily the Vaniar Reservoir Project is designed to provide irrigation facilities to a new dry ayacut of 8550 acres (3462 ha.) and to improve irrigation in an existing - largely wet ayacut of 1852 acres (750 ha.) both spread over 16 (sixteen) villages in Harur taluk of Dharmapuri District. It is expected to result in additional food out put of nearly 10,000 tonnes. Indirectly the storage and distribution system would increase the ground water potential in the ayacut as well as the adjoining non-ayacut lands in this part of a backward district which can open avenues for lift irrigation. Since the lands coming under the influence of this project are found to be fit for all types of cultivation the economic well-being of the farmers is bound to go up. The storage system serves as a flood moderator too. Other tangible benefits are drinking water supply and fisheries development. Possibilities of limited water supply to industrial use are also not ruled out in this case. It may not be out of place here to refer to the following inscriptions in the tablet stone at the upper Anicut after regulators across the coleroon arm of Akanda Cauvery was built in the year 1845. The benefits to the posterity is immesurable.

1.3 The registered wet lands viz. the old ayacut under this scheme are fed by channels taking off from 4 (four) old anicuts across Vaniar either directly or through tanks. The river originates from the northern slopes of Shervarayan hills. Flood flows in the river are only seasonal. The lands suffered from the vagaries of monsoon. Since a storage reservoir is now put up., and priorities of supplies for old existing irrigation are built in the rules of the irrigation releases crop failures which occurred at times before can be completely avoided and the yields of crops too increase.

1.4. The cost of modern storage irrigation system is high and the investments there on will not be economical if it caters to old ayacutdars and some new agriculturists who, likewise, practise wet cultivation only. The benefits had to be spread out. Incidentally the storage at higher altitudes has the inherent facility of extending irrigation to larger areas in addition to the existing ones along the narrow margins of the river down below. Invariably the policies of socialist Governments are to make the new irrigation potential available to as large a population as possible and restrict the numbers getting affected by the creation of such facility by way of displacements due to submersion and space required to form the reservoir etc. to a minimum. With these objectives in view, various options were exam-

ined and the present scheme with a storage capacity 418 M.cft. (11.83 Mm³) across Vaniar to enable dry cultivation in 8550 acres (3462 ha.) unveiled. The various alternatives tried, the proposals examined and dropped both during British Rule and post independent India are detailed in the ensuing chapters.

1.5 The Salient Features of the scheme finally taken up for implementation are given below:

1.5.1 GENERAL INFORMATION

a) Location

Latitude 12° 54' 30"., Longitude 78° 20' 30". 4.5 km from Venkatasamudram village which is 3 km from Pappirenddipatti on the Pappirendipatti - Mallapuram Road in Harur Taluk of Dharmapuri District.

b)	River	-	Vaniar
c)	Basin	-	Pennaiyar
d)	Construction Period	-	1979 to 1985
e)	Cost (Revised)	-	Rs.1203.10 lakhs
f)	Expenditure upto 2/1993	-	Rs.1114.85 lakhs

1.5.2 RESERVOIR

	In Metric Units	In F.P.S. Units
Free Catchment Area - Combined Area - Equivalent Area	101.76 sq.km	39.29 sq.miles
Capacity at FRL	11.837 Mm^3	418M.Cft
Number of Fillings	2	2
Annual Storage	23.67Mm^3	836 M.Cft. (with
Dead Storage	0.8 Mm^3	28.3M.Cft.
Water Spread Area	109.3 Ha.	270 acres
Full Reservoir level	471.00m	1545ft.
Maximum water level	471.00	1545ft.
Top of bund level	474.00	1555ft.

1.5.3 EARTH DAM

Total Length	1136m	3726 ft.
Top Width	3.65m	12 ft.
TBL	474.0m	1555
Free Board	3m	10 ft.
Maximum Height	31.17	105 ft.

1.5.4 SURPLUS REGULATOR

Number of Spans	3os.11.3m & 4.5m	37 ft. x 14ft.
Maximum Flood Discharge	654.9 cumecs.	23120 cusecs
Crest Level	466.50	1531 ft.
Location at	L.S.340m	

1.5.5 TOWER HEAD SLUICE (LEFT SIDE)

Location	800m	
Sill level	451.1m	
Vent size	1 no.1.5mx1.8m	1x5'x6'
Discharge	1.4cumecs	49.52 Cumsecs
Ayacut	1639ha.	4050acres

1.5.6 TOWER HEAD SLUICE (RIGHT SIDE)

Location	1250m	4100 ft.
Sill level	451.10m	1479.6ft
Vent size	1 no.1.5mx1.8m	5'x6'
Discharge	2.14cumecs	75.75cusecs
Ayacut	1821.15ha.	4500acres

1.5.7 LEFT SIDE CANAL

Length	19.2km	
Bed Width	1.2m	4ft.
Full supply depth	0.70m	2.3ft
Velocity	0.699m/sec.	2.20ft/sec
Discharge	0.93cumecs.	32.8cusecs
Ayacut	1639 ha.	4050acres

1.5.7 RIGHT SIDE CANAL

Length	12.74km	
Bed width	1.8m	6ft
Full Supply Depth	0.8m	2.63ft
Discharge	1.48cumecs.	52.3cusecs
Ayacut	1852 ha.	4500acres

1.5.8 RIVER SLUICE

Sisnce deleted. Supply is arranged through right main canal sluice and right canal which has a bye-pass connecting to river course.

REVENUE AND FINANCIAL

Net Additional Food Production	9887 tonnes	
Cost per tonne	(a)	Rs.5664 on original estimate
	(b)	Rs.12168 (Revised) estimate
Cost per acre	(a)	Rs.5384 on original estimate
	(b)	Rs.11566 (Revised) estimate
Net Revenue expected	Rs.1,86,703 (without betterment levy)	
	Rs.2,76,833 (with betterment levy)	
Percentage return	0.3334 (without betterment levy)	
	0.4943 (with betterment levy)	
Benefit Cost ratio	at 5% interest 2.51:1 (on original estimate)	
	at 10% interest 1.38:1 (on original estimate)	
Duty adopted	14 acres per M.cft. for dry crops 25 acres per M.cft. for stabilisation.	

CHAPTER 2

PRELIMINARY INVESTIGATIONS AND PROPOSALS

EARLIER SCHEMES TRIED AND THEIR FATE

2.1 The Vaniar Reservoir Project was thought of as early as 1877. It was Mr.Lofanna who was the Collector of Salem for many years mooted the idea. The details of the old project are available in G.O.Ms.No.2783 dt.12.09.1911.

2.2 The earliest investigation of the Project was carried out by Capt. Jakson, Executive Engineer on Famine Duty in Salem District. He proposed a storage reservoir of 324 M.cft. capacity across the river Vaniar near Mullikadu village to irrigate an extent of 3,000 acres in and around the adjacent villages. The project cost was estimated to be 1.75 lakhs, with a return of 6.25 percent.

2.3 Subsequently the scheme was revised by Mr.Scott to irrigate an extent of 6,000 acres. Since the anticipated return was good the scheme was ordered to be proposed under famine relief programme.

2.4 The scheme was again revised by Capt. Romily, Executive Engineer, Salem Divn. This time, the reservoir was proposed to be constructed near Pappireddipatti Village to hold 957 M.cft. of water and to irrigate an extent of 10,500 acres.

2.5 In 1897 Mr.M.O.Connel, Superintendent Engineer recorded that the scheme was unworkable for the following reasons:

i) The catchment of the river lies on the northern slopes of Shervayayan Hills. It cannot receive south-west monsoon rains. Hence floods could be expected during the months of October to December only.

ii) The sites selected by both Capt. Romily and Capt. Jackson were not suitable for a dam as it is doubtful that solid rock would be found within a reasonable depth.

iii) Yield availability appeared to be over-estimated. At 60 acres per sq.mile of catchment it could not irrigate as much ayacut as proposed.

iv) There was no doubt that the soil was excellent and many types of crops could be grown.

2.6 The Chief Engineer (Irrigation) upheld the above views and the scheme was shelved accordingly.

2.7 Again in the year 1906, Thiru Arokyasami Mudaliar, Executive Engineer, Investigation for Salem and Coimbatore Districts investigated the proposal and agreed with the Superintendent Engineer, Mr.Connel's findings that the catchment at the sites chosen earlier was very small and the yield had rather been overestimated. The storage capacity at the site was also not very advantageous

since the valley here was very narrow being bounded by steep hills. There was no convenient place available for the surplus. However, the chief point in favour of this site was that the large extent of good fertile and almost level lands are available compared to the undulating country and steep ground slopes met with lower down the river.

2.8 Therefore, the Executive Engineer (Investigation) selected an alternative site - 3 miles west of Harur just below the infall point of Kallar (Thurinjahalli River) into Vaniar. The catchment at this site is 257 sq. miles out of which 103 sq.miles are upon the hills. A reservoir with a capacity of either 1133 m.cft. (with FRL at +767 ft.) or 2546 m.cft. (with FRL at +780 ft.) to irrigate an extent of 25600 acres was proposed. He pointed out that about 2 miles of Salem Thirukoilur Road would be submerged if the above scheme is implemented and the formation of an alternative stretch of road between Pallipatti and Thenkaraikottai has to be included in the project cost to restore the link. Another important point to be considered is the quantity of water available for new irrigation.

2.9 As afore-mentioned, the hilly portion of free catchment of Vaniar is 103 sq.miles and the plain country catchment is 154 sq.miles. The Executive Engineer estimated that a total 6500 M.cft. yield would be available on the basis of 50 inches of annual rainfall for Shervaroy Hills and 30 inches for plains down below. Leaving 300 M.cft. for the then existing irrigation under Vaniar, it can contribute a balance of 6200 m.cft. to Ponniyar. The Executive Engineer (Thiru Arokyasami Mudaliar) found that the surplus over Thirukoilur Anicut (across Pennaiyar) was not encouraging and the tributary Vaniar being a chief source of supply for irrigation under the present river in South Arcot District, any abstractions for new irrigation under Vaniar would be at the expense of Thirukoilur anicut and lower down systems and therefore he did not recommend the scheme.

2.10 The Chief Engineer (Irrigation) accepted the view of the Executive Engineer. He recorded that the irritable area of about 46,000 acres under Thirukoilur Anicut system plus the ayacut of 22,000 acres under other direct channels taking off above and below the Thirukoilur anicut from Pennaiyar besides the irrigation in French territory depended on the flows of Vaniar river to a considerably large extent. More over, the proposed Krishnagiri Project which was also under examination then would absorb the flood waters of Pennaiyar river in its upper reaches. Gaugings of the Pennaiyar river at key locations have to be carried out before the question of surplus yield is finally settled. For these reasons the then Chief Engineer irrigation considered that the investigation of Vaniar Scheme should be deferred.

2.11 In the year 1923, the Vaniar Project was again examined and again abandoned for the reason that the existing irrigation lower down in the Pennaiyar would be affected. It may be of interest to note here that this contention has proved to be wrong later.

2.12 The question of utilisation of the waters of Vaniar by the construction of a simple dam came up again for examination in the year 1944 as a result of a Memorandum sent to the Chief Engineer (Irrigation) by Salem District Agricul-

tural Association. It appears that this project might not have been referred to the local engineers. For the Chief Engineer Irrigation, himself observed in Memo No.4339/14/-B-3 dt.11.2.47 that a scheme for direct flow irrigation was not possible and the feasibility of diverting a part of floods in Vaniar by an anicut and channels to one of the existing tanks may be examined and reported. To this instruction of Chief Engineer Irrigation, the Superintending Engineer, Coimbatore Circle in his letter No.8311 dt.29.3.47 informed that the diversion of floods in to any tank may not be feasible and the only best proposal would be to form a reservoir across the river Vaniar. This was accepted by Chief Engineer, Irrigation in no.4339/44-B5 dt.26.11.47 and accordingly the proposal was included in the list of schemes to be investigated by the Special Sub-Division to be formed at Krishnagiri.

ALTERNATIVES INVESTIGATED

2.13 The scheme was taken up for investigation by the Special Sub-division during 1949. Two reservoir sites across Vaniar, one near Harur and another near Pappirendipatti were chosen, treating them as two independent schemes. The distance between the two is hardly 12 (twelve) miles. It was thought wise not to take up detailed investigation of both but to do surveys of essential items such as L.S. along dam line, water spread and collect field data like the prospective ayacut to be irrigated, required length of canal etc. to assess the approximate cost of the schemes at these two locations and then select the best one for undertaking detailed investigations.

2.14 The details collected and worked out in respect of the above two sites are presented below:

S. No.	Details	Harur Site	Pappireddipatti Site
1.	Catchment (in sq.miles)	274.4	42.7
2.	Average Rainfall (inches)	33.08	48.0
3.	F.R.L.proposed (ft.)	1190.0	1490.0
4.	Capacity proposed (M.cft.)	480.0	430.0
5.	Maximum height of Spillway above bed level (ft.)	47.0	65.0
6.	Length of spillway (ft.)	421.0	210.0
7.	Land acquisition (Acres)	676.4	500.5
8.	Cost of land acquisition	Rs.2.41 lakhs	Rs.0.54 lakhs
9.	Total length of earth dam (ft.)	8679	3640
10.	Maximum height of Earth Dam	45ft.	60 ft.
11.	Ayacut proposed (Acres)(wet)	3500	2810
12.	Length of Canal - both sides (mile)	16	7
13.	Total cost of the scheme (Lakhs)	55	45.7
14.	Percentage return	0.88	0.86

2.15 Over and above these parameters, the following factors also came up for consideration in the matter of selection of the most advantageous alternative.

2.15.1 The catchment area of the Pappireddipatti site is composed mostly of hills. Proposed annual utilisation for irrigation at this site works out to 8.7 inches only against the average annual rainfall of 48 inches. As the proportion of utilisation to the total rainfall works out to nearly 1/6, there is no doubt about the availability of supply at the upper site - viz. Pappireddipatti.

Pappireddipatti Site

Proposed utilisation 2 x 430 = 860 M.cft.

Depth over catchment of 42.7 sq.miles = $\frac{860 \times 10^6}{42.7 \times 5280 \times 5280}$ = 0.73 ft. or 8.7"

2.15.2 Though the Harur site spillway is 18 ft. lower than the other, its length is much more - nearly twice that of Pappireddipatti. It was shown that there is a saving of 6.5 lakhs in the cost of masonry spillway alone, if the Pappireddipatti site is chosen.

2.15.3 The expenses towards earth dam construction and land acquisition are less in the case of the upper site.

2.15.4 The ayacut available for Pappireddipatti is more fertile when compared to Harur area and the ryots in the upper reaches were found to be more irrigation minded.

2.15.5 About a mile length of Salem-Harur Road will be submerged in the case of Harur site and the cost of diversion road worked out to Rs.2.68 lakhs which is an extra cost.

2.15.6 The Harur site is only about 10 miles above the infall point of Vaniar into the rive Ponniyar and the ayacut of Harur reservoir site will be almost at the tail end. Therefore, any future extension of irrigation would be limited. Whereas, the upper site has always the advantage of its benefits being extended to lower reaches in case its post operation performance analysis results in additional availability of water.

2.16 Considering all the above factors the Pappireddipatti site was considered as the best of the two and further detailed investigation was concentrated upon this site.

2.17 As the next and essential step, the question of total yield available and the yield that could be safely used for new irrigation at this site was examined with due care and consideration. The various aspects taken into account in this context were as follows:

2.17.1 No gauge readings at a point in the river course immediately above the proposed (selected) site for Vaniar Reservoir were available. It is ascertained that no gaugings were done before for the Vaniar River. Therefore the probable availability of supply was computed according to Strange Tables. The rainfall assumed in the calculations is the average between the annual rainfall of Yercaud (65.04") and that of Pappireddipatti - i.e. $\frac{65.04 + 30.86}{2} = 47.9$ inches.

2.17.2 The average annual yield for a period of 22 years beginning from 1927 was worked out as 1348 m.cft. with 9 years above this average and 13 years below it if the catchment was taken as good. But the same (average annual yield) reduced to 997 m.cft. if the catchment was considered as bad. Even this minimum figure is more than the annual requirement of 860 M.cft. (i.e. 2 x 430). Therefore it was established that there need be no apprehension about the availability of supplies at the proposed Vaniar site near Pappireddipatti.

2.17.3 The Chief Engineer, Irrigation after inspection of Pennaiyar and its tributaries in September, 1947 issued inspection notes in No.2425/43-B dated 29.10.1947. It was held that out of the total relishable yield of Pennaiyar river, the quantum that could be allowed to be utilised in Salem District was of the order of 3,000 M.cft. and if proposed requirements of Krishnagiri reservoir project and one or two other irrigation schemes contemplated for inclusion in the first five year plan were deducted from this allocation of 3,000 M.cft. the balance left out for new proposals will not be adequate.

2.17.4 On this principle, the Krishnagiri Reservoir Project in the then Salem District was taken up and other schemes were shelved.

2.18 After the commissioning of Krishnagiri Reservoir and Sathanur reservoir projects, gaugings were conducted at Sathanur reservoir and Thirukoilur Anicut for 10 (ten) years. Based on these results and observed flows at upper sites the hydrology of river Pennaiyar was prepared by the Superintending Engineer, Planning and Designs, Irrigation. The results were examined by the Superintending Engineer, PWD. Coimbatore Circle who in his reference No.D2/13508/663 dated 1.2.67 ordered to take up Pambar and Vaniar Schemes for investigation. Pambar is another tributary to Pennaiyar on its left side.

2.19 The second series of investigations for the Vaniar scheme after independence was taken up by the Project Investigation Division Salem. While resubmitting the scheme estimate in his letter No.RC/1823/67.D2, dated 25.9.71, the Executive Engineer, P.I. Division, Salem remarked that the total available quantity in Pennaiyar at the point where the Thumbal anicut is put up across Pennaiyar was in the order of 21947 M.ct. (621.4 Mm^3). The requirement for the then existing total ayacut under Pennaiyar was 15473 M.cft. (438 Mm^3). The surface flow in the whole of Pennaiyar is estimated to be of the order of 57.9 T.M.C. (1640 Mm^3). From the study of inflows and outflows for 4 years at Sathanur, it was seen that the surplus available at Sathanur site itself is of the order of 21800 M.cft. (617.2Mm^3). Even after considering the requirement for Sathanur right bank canal scheme which was being contemplated at that time there would still be sur-

plus. Therefore, the question of detrimental effects to existing and oncoming irrigation schemes in the parent Pennaiyar river did not arise.

DECISION OF THE LOCATION OF THE PROJECT

2.20 Accordingly the old proposal of putting up the dam at Mullikadu Village limits was revived and the scheme estimate for the reservoir across Vaniar with a capacity as before 11.84 Mm^3 (418 M.ct.) was submitted to the Superintending Engineer, PWD. Salem-Dharmapuri circle submitted plans and estimates for this (old) alignment costing at Rs.148.49 lakhs in his Circle No.35602/JEI/ dated 19.11.71 to the Chief Engineer, Irrigation. The area to be benefited was fixed at 3710 acres (1502 ha.) only at that time. It was perhaps all wet.

The estimate was returned with remarks in Chief Engineer's No.B4/ 44509/70, dt.13.03.72.

The Chief Engineer, Investigation sent preliminary estimate for approval under Part II scheme for 1978-79 in his No.B4/20069/72, dt.26.02.76.

2.21 In the meantime, the villagers of Mullikadu village raised a strong objection. They were very firm that not only their village but also a large extent of cultivable wet lands belonging to them should be prevented from submersion. Hence it became necessary to select a new site to accommodate their demands,.

2.22 The Superintending Engineer, PWD. Salem-Dharmapuri Circle inspected the site and instructed to shift the location of the reservoir 1 (one) mile upstream to minimise the submersion of the hamlet of Mullikadu and its costly lands. It was suggested that an earth dam section as formed in Manimuthar Scheme be adopted in the case of Vaniar instead of the section adopted in lower Bhavani Project. It was also remarked that the FRL of the reservoir be raised in such a way that the lands lying between the old alignment and the new alignment are also brought under cultivation.

2.23 It may be noted here that such acquiescence to public pressures is not uncommon. In his technical document on Krishnagiri Reservoir Project, Thiru A.Mohanakrishnan former Chief Engineer, General and Irrigation, PWD and presently Chairman of the Cauvery Technical Cell. Madras recorded his comments as follows:

Arriving optimal capacity of reservoir with reference to yield availability at site and depth capacity curves developed through topographical (levelling) surveys may be a theoretical exercise. Certain other important factors obtaining on ground throw up constraints for a theoretical approach. Finalisation of proposals for Krishnagiri Project shows how several alternatives and key factors are to be kept in view in coming to a decision. The key factor in this respects the submersion of villages and valuable lands. Besides actual property loss, human problems had to be confronted; namely the unwillingness of the people to abandon their homes even if rehabilitation is planned at project cost.

The problems confronted in these two cases in respect of alternatives for fixing reservoir alignments are presented below:

Proposals	Villages Submerged	Population Affected	Dwellings Coming under Water			Mosques, Temples, etc.
			Thatched	Tiled	Terraced	
Krishnagiri						
(a) FRL 1590 MWL	7	5156	659	79	15	19
(b) FRL 1577	3	2467	293	23	3	12
Vaniar						
(A) Original Mullikadu Site	Not Available (N.A)					
(B) Site 1 mile above Mullikadu	Nil	Negligible	45	6	Nil	Nil

Note: In the case of Krishnagiri, proposal (A), was recommended on account of higher percentage of return and larger benefits. In the meantime pressure built up to deter the Krishnagiri project since a rich village, Gangaleri, was affected. Further investigation to save atleast Gangaleri was ordered. FRL was later brought down to 1585 ft. giving a capacity of 2410 M.cft. leaving MWL at 1590 ft. Government sanctioned the Krishnagiri Project at a cost of Rs.184 lakhs on 23.11.54 Inauguration was organised on 3.1.55 with a special armed police protection as physical obstruction by affected villagers was feared.

CHAPTER 3

CORRESPONDENCES RELATING TO THE FORMULATION OF THE SCHEME

A selective list of important references, inspection notes of higher authorities, replies furnished by local officers, etc. in formulating the Vaniar Reservoir Project is given below:

S.No	Reference Number of Correspondence	Subject Matter and Brief about the Content	Remarks
1.	G.O.Ms.No.2783 dated 12.9.1911	Details of old (earliest investigated) project are available	
2.	Memo No.4339/14/B3 dated 11.2.1947	Observation of the Chief Engineer (Irrigation)for discussion and then decision to go in for a storage scheme.	
3.	Memo No.4339/44-B5 dated 26.11.1947	Soils suitability of Vaniar	
4.	Letter No.8311 dated 20.3.1947 of Superintending Engineer PWD, Coimbatore Cirle	Suggesting best proposal is to form reservoir	Accepted by Chief Engineer (Irrigation) and included in the list of schemes to be investigated.
5.	Letter No.RDIS.5789/74 dt.31/12/74 of District Agricultural Officer. Krishnagiri	Soils suitability of Vaniar Ayacut area in certain villages was examined and reported.	Annexure I favorably recommended
6.	Letter No.B4/20069/72 dated 26.2.1976 of Chief Engineer, Investigation	Preliminary estimate for the scheme was sent to Government for approval under Part II schemes for 1978-79.	
7.	Circular Memo No. B1/703732/762 dated 10.11.1976 of Chief Engineer Investigation	Check list for furnishing the details along with the designs for components of Irrigation Project.	General Circular on Questionnaire pattern
8.	D.O.No.D1/61540/77-4 dated 1.8.1977 of Chief Engineer, Investigation	Superintending Engineer, PWD, Project Investigation Cirlce PWD Tiruchi was instructed to prepare detailed design and drawing for various components of the scheme.	Copy of this letter was also marked to Superintending Engineer. Designs, Madras. He was directed to complete the design components before 17.9.1977.
9.	Letter No.Camp/77/177/ F.97 dt.29/8/77 of Executive Engineer, P.I.Division, Salem	Detailed calculations for maximum flood discharge on observed water levels basis submitted.	Observed maximum flood discharge is less than the calculated value
10.	Letter No.223 M/77/DS/F.97 dt.13/9/77 of Executive Engr.P.I.Division, Salem to Superintending Engineer Designs, Salem.	Trial pit particulars along the alignments of the proposed surplus course are submitted.	Hard strata (SDR) was met with at depths of 1.2m at Regulator site and at 0.75 m at surplus course site

S.No	Reference Number of Correspondence	Subject Matter and Brief about the Content	Remarks
11.	Letter No.82CE/E,118/D3 dated 1.4.1977 of Superintending Engineer, PWD, Investigation.	Detailed Plans and estimates for Vaniar Reservoir Scheme near Mullikadu Village were submitted pby the Superintending Engineer Investigation, Trichi.	
12.	Letter No.B4/20069/72-42 dated 20.7.1977 of Chief Engineer Investigation Madras to Superintending Engineer (Irrigation), Trichi.	The above detailed plans and estimates were returned to the Supdtg.Engineer with remarks.	Superintending Engineer (Investigation) to attend the remarks numbering 14 and resubmit very early.
13.	Letter No.AE.IV/7089/77 dated 29.8.1977 from Superintending Engineer Designs to the Executive Engineer Investigation Salem	Refers to Executive Engineer's letter containing field particulars for Vaniar Scheme and asking Superintending Engineer Design's to prepare design and drawings for the surplus regulator and surplus course at the left flank. Also it is remarked that the design for the earth dam could not be finalised for want of soil particulars.	Tentative plans/ designs for the surplus arrangements were completed on certain assumptions
14.	Letter No.B4/81038/77-1 dated 17/9/77 of Chief Engineer, Irrigation	Notes of Inspection of date 7.9.1977. Suggestions to shift the alignment and to explore possibilities of having wet ayacut only with high duty (80 acres per cusec) Fixing the entire new area for sugarcane may also be examined.	Vide Annexure
15.	Letter No.AEE-IV/7089/77 dated 30.10.77 of S.E. Designs to Chief Engineer, Investigations	Superintending Engineer Design's comments on the various alignments and recommendation for finalisation.	
16.	Letter No.AEEIV/7089/77 dt.22.4.78. from Supdt. Engineer, designs to Chief Engineer, Investigation	Earth dam typical sections and Stability analysis for Vaniar Reservoir scheme submitted	Vide Annexure Based on the Minutes of Discussions with C.E. (Investigation) dt.8.8.78.
17.	G.O.Ms.No.284.PWD dt.20.2.79.	Government sanctioned the scheme and revised proposal for Rs.560 lakhs as per Governments letter PWD No.18190/ Q2/79-1 dt.6.4.79.	Sent in the place of earlier proposal for Rs.540 lakhs
18.	G.O.Ms.No.994 Forest and Fisheries Department dt.14.3.79.	Forest areas involved in the formation of Vaniar Reservoir orders issued.	Ordered that an extent of 131.56 acres of forest land be placed at the disposal of PWD.

CHAPTER 4

DETAILED INVESTIGATIONS TO SELECT ALTERNATIVE SITES

4.1 As mentioned before, during the initial stage itself preliminary investigations were carried out in the following sites:

1. Mullikadu Village Site - 5.5 km away from Pappireddipatti
2. Harur Site - 3.5 km west of Harur

The second proposal was not pursued.

PRELIMINARY ESTIMATES AND CONSIDERATIONS

4.2 The Chief Engineer Investigation in his letter No.B4/20069/72 dated 26.2.76 sent to Government a preliminary estimate for the Vaniar Scheme for approval under Part II scheme and on 1.8.1976 instructed the Superintending Engineer Investigation Circle, Trichy to prepare detailed design and plans and drawings for the various components of the scheme. A check list in questionnaire form prescribed by the Chief Engineer Investigation for sanction and approval of estimates based on the drawings etc. was also asked to be duly filled in. This check list is annexed for reference.

4.3 During his site inspection on 07.09.77. the Chief Engineer Investigation remarked that the width of the Valley is almost 1/2 (half) at a distance of 1/2 km upstream of the alignment put up for his approval (original) and it may be worth while to consider this upper site as an alternative even if the capacity had to be less. A lot may depend upon the surplus disposal arrangements needed. The Chief Engineer Investigation was also of the opinion that the extent of new irrigation may be fixed on the basis of a high duty wet crop since the cultivable lands in the command area are mostly composed of clay with high moisture retentive capacity. He suggested that a duty of 80 or so may be adopted and the capacity of the reservoir adjusted accordingly. Vide Chief Engineer's letter No.B4/81038/77-1 dated 19.9.77.

4.4 Closely following the Chief Engineer's above site inspection, plans showing the alignments originally fixed, that suggested by Chief Engineer and some other alternatives are got prepared expeditiously by the Executive Engineer, Investigation Division Salem and produced during the site inspection on 27.10.77 by Superintending Engineer, PWD Designs Circle, Madras. The merits and demerits of the various alternatives were also furnished.

DESIGN CIRCLE'S FINDING ON THE VARIOUS ALIGNMENTS

4.5 The designs Superintending Engineer's remarks on the alternative places inspected were on the following lines.

4.5.1 The original alignment ABC was indeed very long and had this been followed considerable extent of fertile lands would get submerged. Besides some rehabilitations would be required on account of submersion of developed areas. No proper foundation rock for putting up spillway was found available at this site.

4.5.2 Borings were being done along the alignment E.F. marked in the Plan. No rock at reasonable depth was found available at alignment E.F. as well. The two borings so far done along this (EF) alignment did not so far indicate rock. Results of further borings were awaited. Local people informed that sheet rock may be met with along a line, 50 (fifty) meters upstream of this EF line on the left flank.

4.5.3 However, there were more positive indications of good foundation grade rocks being met with along the III alignment - viz. P.Q. which is 500 to 600 meters away from E.F. on the upstream side. At this site, the height of the dam has to be increased to retain the required capacity fixed before. Secondly, it may not be possible to accommodate he entire borrow areas for earth for embankments within the water spread and earth for bund formation may have to be brought from lands to be specially acquired for this purpose elsewhere below this alignment. More over the lengths of canals and approach roads to be formed on both sides for irrigation would be increased involving extra expenditure on these sub-heads. The savings in foundations of the dam at this upper site (P.Q.) would be off set by these considerations.

4.5.4 An alignment between XY and R.S. in the map where the river width is narrowest may be preferable. The side slopes here are steep and sound rocky base to found spillway block would be available at a much higher level. This may result in savings in cost of constructions of all the necessary component works to accommodate almost the same capacity and pass the calculated flood discharge. Borrow earth also could be taken within the water spread in this case. However, further explorations and estimations of comparative costs of construction of the various components at all these alternative alignments are to be done before a decision on the final location of the dam is taken. Vide letter No.A.E.E.IV 7089/77 dated 31.10.77 of Superintending Engineer, PWD, Design Circle Madras addressed to the Chief Engineer Investigation, Madras.

4.5.5 An alignment little above the originally proposed was finally chosen. This alignment ran clear of the hillock situated on the left margin of the river. It was considered that a portion of the hillock may get absorbed in the semi pervious zone of the earth dam. This alignment was favoured because the submersion of forest lands may be kept minimum.

CHAPTER 5
HYDROLOGY

5.1 FEATURES OF THE PARENT RIVER

5.1.1 The Pennaiyar river originates from the south-eastern slopes of the Chenna-Kesava hills in the Karnataka State at an altitude of 1000 M above mean sea level. The river basin is sandwiched between Cauvery basin on its west and south and Palar and Thondiar basin on its north and east sides. It is located within the geographical co-ordinates latitudes 10° 30' and 130° 40' north and longitudes 71° 10' and 73° 16' east and has a total area of 15,100 sqkm (5,830 sq.miles) of which 1257 sq.km. (4,346 sq.miles) falls within Tamilnadu boundary. The river flows through Dharmapuri, North Arcot, Sambuvarayar, South Arcot Ramasami Padayachi and South Arcot Vallalar Districts and finally falls into the Bay of Bengal.

5.1.2 The main river has many tributaries and sub tributaries as given below. Vaniar is one of the tributaries.

Sl. No.	Tributaries		Sub-Tributaries
1.	Chinnar I		
2.	Chinnar II		
3.	Markandanadhi	3.1	Nachikuppam Nadhi
		3.2	Veppanappalli Nadhi
4.	Poolappatti River		
5.	Pambar	5.1	Semmandakuppam Ar
		5.2	Bargur Ar
		5.3	Kanar
6.	Vaniar	6.1	Kallar (Thurinja Halli River)
		6.2	Varattar
		6.3	Meenar
		6.4	Peeniar
7.	Kallar		
8.	Pambhar		
9.	Musukkanda Nadhi		
10.	Thurinjalar		

5.1.3 IRRIGATION SCHEMES IN PENNAIYAR

The two major reservoirs across the main river are Krishnagiri and Sathanur Dams which were built up during the First Five Year Plan period. Krishnagiri reservoir has a capacity of 85 Million cubic metres (about 3 TMC) and irrigates 3,642 ha. (8996 acres). The corresponding figures for Sathanur reservoir are 228 million cubic metres (about 8 TMC) and 9,010 ha. (22,255 acres). Later in the seventies the ayacut under Sathanur was extended to a further extent of 8,505 ha. (21,007 acres) after excavating a new canal on the right side of the river. A small storage scheme to hold about 17 M cubic metres (600 m.cft.) was put up at Keleverappalli near Hosur in the head reaches for irrigation and industrial and domestic water supplies in Hosur taluk of Dharmapuri district. This work was started in the year 1977 and completed 14 years later. But this is not yet become fully functional due to litigations regarding compensations for lands which gets submerged when water upto FRL is impounded. A number of anicut schemes are also operational in the parent river, Nedungal Anicut, Thirukkovilur Anicut and

Ellis Choudhuri Anicut are the oldest and largest in this category. Other small and medium run-off the river schemes total to 16 (sixteen) numbers of which Aliyalam, Thumbal and Iachambadi are being worth mentioned. There are as many as 41 open off take channels in this main river in its entire run in Tamilnadu. The ayacut details of the various storage and diversion schemes across the main river as well its tributaries are given below.

Pennaiyar Basin : Details of system ayacut (in hectares)

Sl. No.	Description	Single Crop	Double Crop 1Crop	Double Crop IICrop	Remarks	
1.	12 Anicuts upto Krishnagiri Reservoir	550	-	-	Wet Crop	
2.	Sulagiri Chinnar Reservoir	-	353	353	Irrigated dry crop across tributary	
3.	Krishnagiri Reservoir	3,642	-	-	Wet Crop	
4.	Nadungal Anicut	1,760	-	-	Wet Crop	
5.	Kumarapatti Anicut	57	-	-	Wet Crop	
6.	Tambal Anicut	46	-	-	Wet Crop	
7.	Pambar Reservoir	1,619	-	-	Irrigated dry crop across tributary	
8.	Thumbalahalli Reservoir	884	-	-	-do-	
9.	Vaniar Reservoir	3,460	-	-	-do-	
10.	Kelavarapalli Reservoir	3,240	-	-	-do-	
11.	Iachembadi Anicut	2,529	-	-	-do-	
12.	Sathanur Reservoir Project					
	a) Left Bank Canal	9,717	-	-	Paddy	3,200
					Sugar Cane	680
					Groundnut (Single crop)	5,520
					Other I.D.Crops	317
						9,717
	b) Right Bank Canal	8,505	-	-	Paddy	2720
					Sugarcane	646
					Groundnut (Single Crop)	4834
					Other I.D. Crops	305
						8,505
13.	Open Offtake Channels (19 Nos.) between Sathanur Reservoir and Tirukkoilur Anicut	1,875	-	-	Wet Crop	
14.	Tirukkoilur Anicut	6,885	2,025	2,025	The second crop of double crop depends on release of water from Sathanur Reservoir	
15.	Open Offtake Channels 14Nos. between Tirukkoilur Anicut & Ellis Choultry Anicut	2,680			Wet Crop	
16.	Ellis Choultry Anicut	5,065	-	-	Wet Crop	
17.	Open Offtake Channels 8 Nos.between Ellis Choultry Anicut and Sornavur Anicut	2,509	-	-	Wet Crop	
18.	Sornavur Anicut					
	a) Pondicherry State Ayacut	1,932	-	-	Wet Crop	
	b) Tamilnadu State Ayacut	516	-	-	Wet Crop	
		57,471	2,378	2,378		
	Grand Total	59,849 ha.				

5.1.4 HYDROMETEOROLOGY

The rainfall, temperature, humidity, wind velocity, evaporation and evapotranspiration characteristics of the basin were studied and the broad consolations are as follows:

The basin area has monsoonic climate. Both south-west and north-east monsoons bring significant rainfall. The rainfall quantity gradually increases from western to eastern (coastal) parts of the basin. In the western portions, the annual average rainfall is around 800mm, on the central portion it is about 950 mm and in the coastal region it is 1300 mm. The annual rain fall quantity in the basin area lying in Dharmapuri District, is deficient for successful agriculture. The south-west monsoon contributes to the western region and also to he eastern part adjoining the coast a rainfall quantity to the extent of 350mm; the same has however greater influence in the Dharmapuri District.

The mean monthly temperature in the basin varies from 18° C to 32 C and the humidity varies from 50 percent to 100 percent.

The potential evapotranspiration (PET) ranges from 1500 mm to 1600 mm. A comparative study of the annual rainfall and potential evapotranspiration was made for selected stations. The annual deficiency which is the annual rainfall (P) minus the PET is called the potential water deficit, if it is negative.

It was seen that the stations selected have annual water deficit and the range of deficit is around 600 to 700mm in most of the basin area. The maximum deficit is prevalent in Dharmapuri District, the value is around 800mm.

5.2 CHARACTERISTICS OF VANIAR SUB-BASIN

5.2.1 The area of the sub-basins is 1090.5 sq.km (426 sq.miles). Its perimeter is 179.2 km (112 miles). The length and maximum length of the sub-basin are 54.4 km (34 miles) and 59.2 km (37 miles) respectively.

This is the only sub-basin which has streams upto 7th order. The form factor value is 0.36. The circularity ratio is 0.46. Both these values indicate that the basin is moderately elongated. The elongation value 0.55 confirms this.

The bifurcation ratio is 3.94 which is comparatively a low value indicating the pervious nature of the sub-surface to a certain extent.

The drainage density is 1.68. The over land flow is 0.29. Both these values indicate that the surface flow is low and hence there is scope for ground water recharge. Kalvarayan hills. Yercaud hills and Krishnagiri hills occupy the three sides of the sub-basin. The drainage density is high in the hilly region. The relief is 7.62 per km. (40 ft. to a mile). The sub-surface seems to be hard in the area. The sub-basin may yield a low sub-extended peak flow.

5.2.2 CLIMATE AND RAINFALL

Climate: The Dharmapuri District as a whole enjoys a dry climate. The hot weather begins early in March. The weather progressively cools down from about middle of June. Being an interior district the diurnal range (variation) of temperature is large - i.e., about 15° C between maximum and minimum temperatures. The highest ever recorded temperature was 43° C and the lowest 11° C. The humidity is generally low.

Rainfall : The hilly terrain causes appreciable variation in rainfall over the district. The annual rainfall varies between 680 mm and 98- mm. Yercaud in Sherverayan Hills - which is however, in Salem District, but which is close to Vaniar Dam site has an average annual rain of 1930 mm (64"). The average annual rainfall in the plains of the district (Dharmapuri) is 849 mm. The monthly distribution of rainfall shows a predominant maximum in October with a secondary maximum in May. A study of rainfall reading over a long period in this districts reveals that the highest rainfall in a best year was 146 percent of the normal and lowest 50 percent the normal.

5.2.3 RIVER COURSE AND CATCHMENT

Vaniar is one of the major tributaries of Pennaiyar river. Vaniar river itself has got four (4) sub-tributaries. It originates in Shervarayan Hills at an altitude of 5316 ft. above mean sea level. close to Yercaud town and it runs for a distance of 22 km (13.75 miles) in hill slopes covered by dense forest before it enters the plains about 5 km above the hamlet of Mullikadu. The river runs for a further distance about 48 kms in the plains before it infalls into Pennaiyar in Ponnagarampatty reserve forest area. Its total length is 70km and it drains 612 sq.miles in all. The catchment above the Vaniar dam is 39.3 sq.miles (102 sq.km) and is subject to the influence of both north-east and south-west monsoons. However, the degree of influence of south-west monsoon is rather less. The catchment above the reservoir site is mostly hilly. In this Vaniar river basin there are 192 irrigation works - i.e. tanks and Anicuts of which 155 belongs to Government.

5.2.4 YIELD AND FLOOD DISCHARGE CALCULATIONS

The yield worked out for this case was based on dry damp wet method and the maximum flood discharge was arrived at using the Ryve's formula taking a generous value 2000 for the constant C ($Q = CM^{2/3}$), M is the catchment area in that formula. The rain fall station taken into consideration is Yercaud which lies just outside the catchment boundary. The average annual rainfall for Yercaud is 159.51 cms (62.84 inches). The dependable yield for this rainfall works out to 22.86 M.cft. per sq.mile based on dry damp wet method. The catchment is very good and hence a factor of 1.25 is adopted for deriving the yield in this case. On this basis, the expected yield is 39.25 x 1.25 x 22.86 = 1098 M.cft. This is a very approximate approach.

A statement showing the theoretical yield calculated for every month for 27 years from 1949 based on daily rainfall and adopting this dry damp wet method is annexed. The average worked to 42 Mm^3 (or 1493 M.cft). This was later found to be very optimistic. The actual average annual inflows into the res-

ervoir ranged from 4.66 Mm^3 (165 M.cft) to 62.2. Mm^3 (2202 M.cft) during the years 1985-86 to 1994-95. The average is 22.2 Mm^3 (786 M.cft.).

Maximum flood discharge : This was worked out as follows : (Ryve's formula)

$Q = C \times M^{2/3}$, where Q is flood generated from a catchment whose area is M, C is a constant to which a value of 2000 is assigned in this case as the catchment is hilly dense forest.

Catchment upto dam site is 39.23 sq.miles

Hence $Q = 2000 \times 39.23^{2/3} = 23120$ cusecs. (654.9 cumecs)

A surplus regulator to tackle this flood is proposed in the left flank.

5.2.5 UTILISATION - WATER BALANCE

The live capacity of the reservoir works out to 11.637 Mm^3 (418.0 M.cft.)

The ayacut to be benefited is 8550 acres new, dry and 1852 acres stabilisation. Besides this provisions for evaporation and transmission losses and provision for dead storage have to be made.

Calculations for requirement of water

i)	For new dry ayacut at 14 acres per M.cft.8550/14	=	610.71 M.cft.
ii)	For stabilisation at 25 acres per M.cft. 1832/25	=	74.08 M.cft.
iii)	Allowance for evaporation and transmission losses at 17 1/2% = $\frac{(610.71+74.08) \times 17.5}{100}$	=	120.00 M.Cft.
iv)	Dead storage	=	28.29 M.cft.
	Total	=	833.08 M.cft.
v)	Balance available 1089-833	=	265 M.cft.

There is still a balance of 265 M.cft. available for further utilisation.

A statement prepared during the investigation stage (in the year 1977) illustrating a theoretical reservoir operation plan is annexed. This showed that the scheme will be highly successful.

CHAPTER 6
GEOLOGICAL STUDIES IN AND AROUND VANIAR BASIN

Source: Water Resources Assessment of Pennaiyar Basin Volume I by the Government of India, Government of Tamilnadu (Ground Water Wing, PWD) and Institute of Water Studies, Taramani, Madras 600 113 - 1986.

6.1 GEOLOGICAL FEATURES

The Pennaiyar basin is built up of Archaean rocks comprising genesis, Charnokites, Pyroximites and Durmites. Younger intrusives which cut across these rocks include synites and Pegmatites. Regional Trend is N.N.E - S.S.W. with varying dips. In the central and western parts of this basin which comprise Vaniar sub-basin fractures and shears are well developed. Folds occur at Samalpatti which is with in 40 km distance from Vaniar river. Faults are noticed near the tributaries Vaniar and Pambar. Land forms of the sub-basin can be broadly classified as Denudational and Fluvial.

The geological studies pertaining to structures in and around Vaniar sub-basin indicate several prominent folds of antiform and synform structures, fault zones and shear zones at several places. The major synform and antiform structures identiied from landstat and confirmed include synform structures north of Veppanappalli in Magnetite quartzite about 70 km north of Vaniar and antidinal fold near Kaveripatnam 55 km from Vaniar and a synchinal fold in Thirthamalai and Harur areas in the Vaniar sub-basin itself.

Faults : The prominent mega lineaments identified and confirmed as faults and fault zones include :

i) N.E. - S.W. trending boundary fault of crystalline sedimentary contact.

ii) N.E. - S.W. trending Attur fault extension across the basin along Vaniar and Pambar.

iii) N.W. extending fault near Sathanur Reservoir and parallel to Sathanur Dam and

iv) Closely spaced N.E. - S.W., N.S., N.N.W.-S.S.W. lineaments in and around Krishnagiri and Thiruppathur areas.

Evidences for these fault zones include topographical variations like off-setting of rivers, hills, dikes and presence of mylonites. The fault and fault zones are some-times open and in several locations filled with mineralisation. The fault zones appear in several locations near the junction of Pambar which is just 10 km from the confluence of Vaniar with Pennaiyar and in Mathur area which is about 35 km from Vaniar sub-basin. The Mathur area appears to be a graban structure.

6.2 HYDRO-GEOLOGY

Borehole lithology of some exploratory bore holes in hard rock and 21 numbers in sedimentary formations, pump set data of 31 horeholes in hard rock and 10 in sedimentary were analysed and water quality data of 139 observation wells located in the basin were studied to know the geological regime of the basin.

Hydrogeological studies indicate the presence of weathered zone upto 15 m below ground level and occasionally with 10m in exceptional cases - north of Dharmapuri, east of Harur etc. Fractures continue upto 60m below ground level. Depth to bed rock and low resistivity zones were delineated for the basin considering the interpreted results of V.E.S. (Vertical Electrical Soundings) and lithology of boreholes. The yield of boreholes range from 27 LPM to 205 LPM. The lithological details of some six numbers of boreholes drilled in Vaniar sub-basin area are as follows:

Borehole No.	Borehole Lithology		Thickness of Jointed & Fractured Zone(m)	Total Depth (m)	Yield in Gallons per Minute (G.P.M)	Remarks
	Depth to Weath-ered Zone (m)	Depth to Bed Rock (m)				
51042	30	90	90	90	-	←Along the
51049	30	60	42	60	20	Tributary on
51017	5	40	24	75	-	on the right
51050	30	84	74	84	30	side
51055	6	60	53	60	-	
51058	6	24	40	42	42	←Near Harur

This confirms the assumption made during investigations during 1977 and 1978 that hard rock could not be met with at reasonable depth below G.L. in Vaniar Dam site. As aforesaid in Chapter 5, the sub-surface in Vaniar area appears to be less hard.

WRCP REPORT ON GEOLOGY OF VANIAR COMMAND

The following details are furnished from the Water Resources Consolidation Project Report for Vaniar sub-basin:

Water table in the command area is generally recharged by the precipitation and applied irrigation. The water table lies between 3m to 20m depth. In most of the cases, the water table is within the weathered portion. During the winter when there is flows in the canals and in the river, the water level rises almost upto ground surface. During summer it goes down to 15m to 20m depth below.

6.3 GENERAL GEOLOGY OF VANIAR COMMAND

Geological formation in the command is of calcareous gneiss and weathered gneiss and soils derived from them are denoted by the Agricultural Department as Harur and Vanampatti series. The latter is yellow-red to red medium textured, neutral in reaction non-calcareous soil developed from weathered gneiss. The soils are well drained externally and the permeability moderate to rapid. The soils are subject to moderate to severe erosions.

6.4. REGIONAL GEOLOGY

Acid charnockites and leptynites are the two prominent rock types occurring in the area (Sankaran - 1968-69). The acid charnockites form the hills in the area whereas the broad valleys and plains are occupied by leptynites (Plates 1 and 2).

Based on field relationships, the following stratigraphic sequence for the area has been proposed by officers of GSI:

Leptynite

Acid charnockite

The regional foliation trends in a general NE-SW direction with south-easterly dips that vary from 50° to 80°. Two sets of joints were recognised. Both are vertical joints and occur at right angles to each other. One set is parallel to the regional gneissosity, i.e. foliation joints and the other one is at right angles i.e. dip joints.

6.5 BACKGROUND INFORMATION

The proposals were formulated as early as 1877. However, the project proposal has been crystallised in 1977 and completed in 1985. Alternative locations have been studied based on engineering and economic considerations. Mainly the Mullikkadu site was taken up for detailed investigation and finally a site was chosen where the rock level was expected to be available at reasonable depth.

6.6 RESULTS OF PRESENT STUDIES

Although the reservoir was just filling due to the on set of monsoon, exposures are limited in the reservoir area. Hence, the area downstream of dam and abutments could only be studied and data projected to the foundation grade of the dam. (Plate - 3).

At the dam site charnockite gneiss with lenses of pyroxene granulite are the country rock. No exposures are seen at the original course of the river which is occupied by only river borne materials. At the right bank the dam is abutted against massive, fresh country rock. At the left side of the left low level sluice for about 100 m width charnockite is exposed from the riverside to hill beyond the surplus course forming a ridge. Although rock is exposed in the vicinity of the spillway/ surplus, it is understood that the structure has been raised from the fresh rock level. Along the surplus channel weathered rock is exposed both in the river bed and as well as in the hill slopes from about 150m downstream of spillway to the left sluice crossing with the surplus. Further downstream till it joins the river course thick overburden is expected. Near the river confluence, soil and kankary exposures are noticed. In the bye wash area rock is not exposed althrough.

The left bank hill which raises steeply is about 500m beyond the end of the dam wherein upto the foot hill soil, scree and hillwash materials are noticed. The earthen dam at the left abutment is abutted against the overburden. At the right abutment

the earthen dam is abutted against the charnockite gneiss with lenses of pyroxene and pyroxene granulite. The exposed rock raises upto 3 to 5 m beyond the top of the dam and further above soil and scree are present. The exposed rock extends about 150m upstream of the dam, while beyond there is again another saddle at a higher elevation. Probably all these features might have been controlling the height of the structures.

The foliation of these rocks trend NE-SW and dip 80° SE. The foliation trend is parallel to the river course. Some of the joint sets are

(i) Strike N 25° to 50° W - S 25 ° to 50° E - vertical - 30 cm to 1.00m spacing, prominent but tight - subparallel to the dam axis.

(ii) Strike N 40° E - S 40° W - dip 70° N 50° W - sparsely spaced - near normal to the dam axis.

(iii) Strike NE-SW - dip 60° to 80° towards SE - near normal to the dam axis - most of the joints are tight.

In the masonry dam there are no records available for either regarding the foundation conditions or the treatments, if any, carried out. But it is understood that the foundation grade rock was met with below 4 to 5 m in this reach. In the earthen dam portion, from the perusal of the records available, the cut-off grade below ground level at different chainages between ch 170 and 350 m - 1 to 4 m, between ch.350 and 500 m - 5 to 6 m, between ch, 500 - 700 m - 5 to 9.15m, between ch. 700 and 800 m - 6 to 10 m, between 800 and 1000 m - 9 to 10.50 m and between ch. 1000 m and the end at the right abutment - 10 to 12 m.

In the surplus channel area the foliation trend is NE - SW and dip 50° to 80°. Foliation trend is near normal to the major portion of the spill channel except in the initial reach till the bend point it is nearly parallel to the surplus channel. Foliation/foliation joints are prominent, spaced at 0.3 to 1.0 m and moderately open at the surface.

6.7 GEOTECHNICAL ASSESSMENT

This is nearly an earthen dam of length 1136 m with a side spillway at the left end of the dam. The masonry spillway has been provided vent for collection of any seepage. The reservoir capacity is 11.837 M cum at F.R.L. and the spillway is designed for a peak flood of 654.90 cumecs.

In the masonry spillway there are neither signs of distress nor cracks noticed. But along the surplus channel carrying the spill water on either bank / embankment, the toe wall used to protect the slope has failed presumably due to scouring. The slope at most of the places is precarious with the slope angle 45° to 70°. Large sized blocks of rocks are dry pitched. Except from the end of energy dissipation arrangement to the confluence / aqueduct of the left river sluice the walls might have been built on rock while beyond, towards the confluence of the river the slope is protected by dry pitching as is done elsewhere probably raised from overburden. It is undertood that the scouring process at the surplus channel is a recur-

ring affair. Model studies may be carried out to assess the scouring pattern while spilling. As a long term remedial measure, the slopes shall have to be suitably dressed and the embankment walls should have to be suitably designed and if rock is found available at reasonable depth they may be founded on rock.

In the earthen bund no sign of distress nor any settlement have been noticed. The toe drains were generally dry at the time of inspection. However, it is suggested to monitor the seepage at the toe drains.

6.8 REGIONAL STRUCTURE AND SEISMICITY OF THE AREA

Structurally the state of Tamil Nadu has been divided into seven tectonic zones which are (i) Chittur Terrane, (ii) Arcot Terrane, (iii) Dharmapuri suture rift zone, (iv) Kollegal - Krishnagiri Terrane, (v) Cauvery suture zone, (vi) Madurai Terrane and (vii) Kanyakumari suture zone. (Plate - 5). All these zones are characterised by structural discordance, variation in bulk lithological assemblages and radioactive data (K. Gopalakrishnan - 1966). These zones are bounded by megalineaments. The other fracture worth mentioning is the NNE-SSW trending lineament at the east, the Pambar fault, at a distance of 30 km. The megalineaments are generally in NNE-SSW direction (Plate - 6).

The area forms a part of the Javadi Hills west zone bounded by Kottapatti fault and Javadi Hills west lineament. The Kottapatti fault is about 20 km east of the dam site. The Javadi hills lineament is about 20 km in the west, in the north is the Palar lineament at about 120 km and in the SSW it is bounded by Moyar - Bhavani - Attur lineament at about 40 km. The Main Fault N 45 ° E and Amirdhi fault are at about 40 km and 20 km respectively from this site on the NW and SE directions.

The Peninsular Shield including the project area has been so far considered to be aseismic, but the scenario has changed and the shield area is now considered to be low to moderately seismic. The dam site falls in Zone - II of the Seismic Zonation Map of India (1893:1984) prepared by Bureau of Indian Standards (ISI) (Plate - 4). During the period from 1821 to 1971, the available records indicate that the area has experienced earthquake shocks < 3 to < 5 magnitude with epicentres at about 20 to 40 km towards West and East. But the cluster of spicentres are mainly towards North and NNW in the east-west pattern from Mangalore to Pondicherry about 60 to 150 km away. The reactivation of Cauvery Suture zone in the Recent times leading to seismic activity was manifested by 1900 Coimbatore earthquake with epicentre about 180 km towards S 55 ° W direction and the felt intensity at the dam site as per the isoseismal map could be V on the mm scale (Basu, 1964, Gubin, 1969).

The structural discontinuties viz. the Mettur fault, Amirdhi fault, Main fault N 45 ° E and Pambar fault are considered to be as part of the series of crustal steep faults. There are a large number and clustering of epicentres recorded in the area with shocks of low to moderate magnitude (Plate-6). This gives credence to the view that it is most likely that the seismicity in this E-W belt is related to crustal readjustments along the rift related fault systems and along the major lineaments.

With the above seismic status background of the project area, the seismic factor, if already provided, for the design of the dam needs to be examined for planning any measures if warranted for safety considerations.

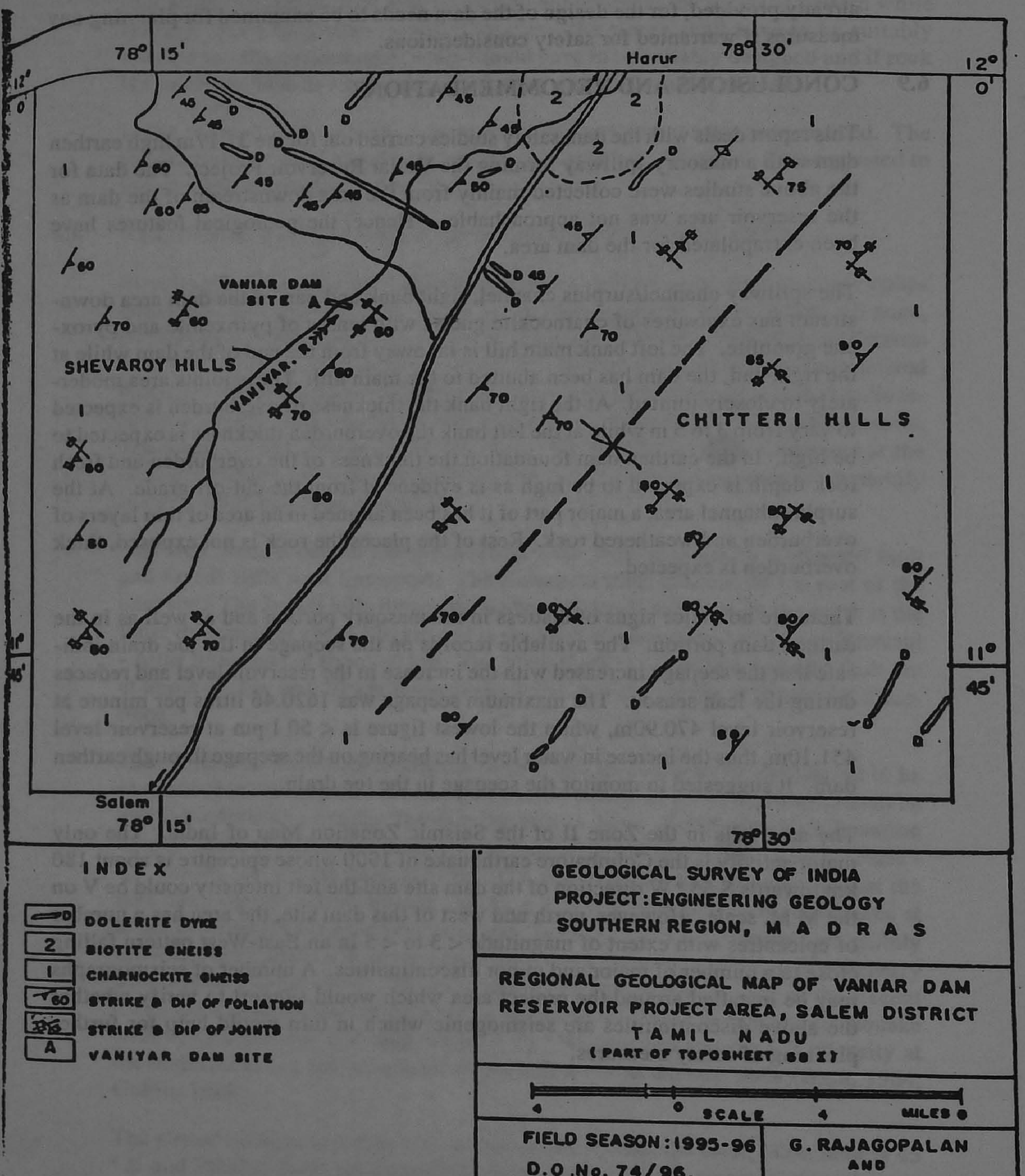
6.9 CONCLUSIONS AND RECOMMENDATIONS

This report deals with the dam safety studies carried out for the 31.17m high earthen dam with a masonry spillway forming the Vaniar Reservoir Project. The data for the above studies were collected mainly from the area downstream of the dam as the reservoir area was not approachable. Hence, the geological features have been extrapolated for the dam area.

The spillway channel/surplus channel, right bank and part of the dam area downstream has exposures of charnockite gneiss with lenses of pyroxenite and pyroxene granulite. The left bank main hill is far away from the end of the dam while at the right end, the dam has been abutted to the main hill. These joints area moderately to closely jointed. At the right bank the thickness of overburden is expected to vary from 3 to 5 m while at the left bank the overburden thickness is expected to be high. In the earthen dam foundation the thickness of the overburden and fresh rock depth is expected to be high as is evidenced from the cut-off grade. At the surplus channel area, a major part of it has been aligned in an area of thin layers of overburden and weathered rock. Rest of the places the rock is not exposed, thick overburden is expected.

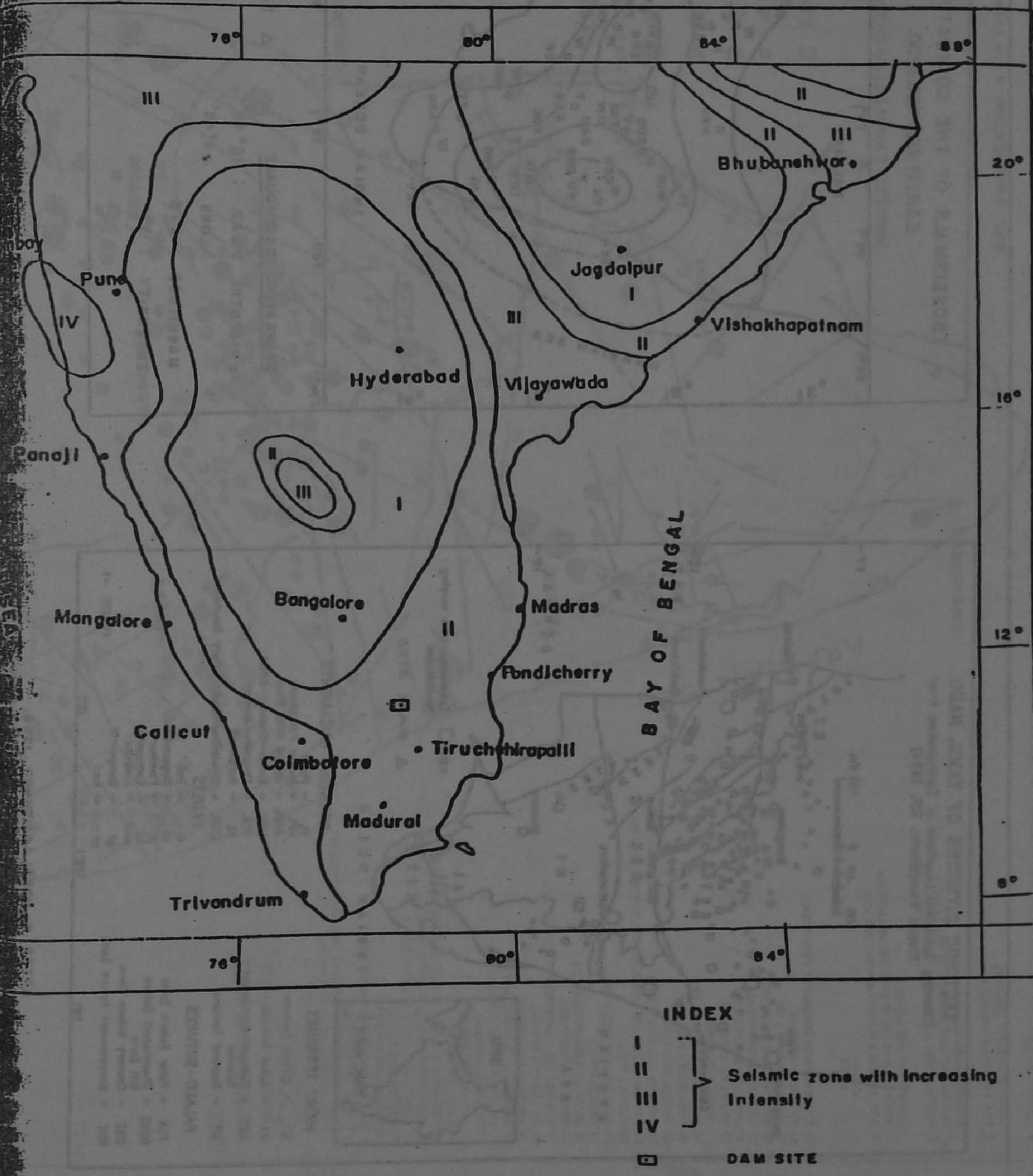
There are no major signs of distress in the masonry portion and as well as in the earthen dam portion. The available records on the seepage in the toe drain indicate that the seepage increased with the increase in the reservoir level and reduces during the lean season. The maximum seepage was 1620.46 litres per minute at reservoir level 470.90m, while the lowest figure is < 50 l pm at reservoir level 451.10m, thus the increse in water level has bearing on the seepage through earthen dam. It suggested to monitor the seepage in the toe drain.

The area falls in the Zone II of the Seismic Zonation Map of India. The only major activity is the Coimbatore earthquake of 1900 whose epicentre is about 180 km towards S 55 ° W direction of the dam site and the felt intensity could be V on the M.M. scale. However, north and west of this dam site, the area has a number of epicentres with extent of magnitude < 3 to < 5 in an East-West pattern falling close to a number of major and minor discontinuities. A number of seismographs may be installed around the project area which would suggest to verify whether the above discontinuities are seismogenic which in turn would help for further planning of safety measures.

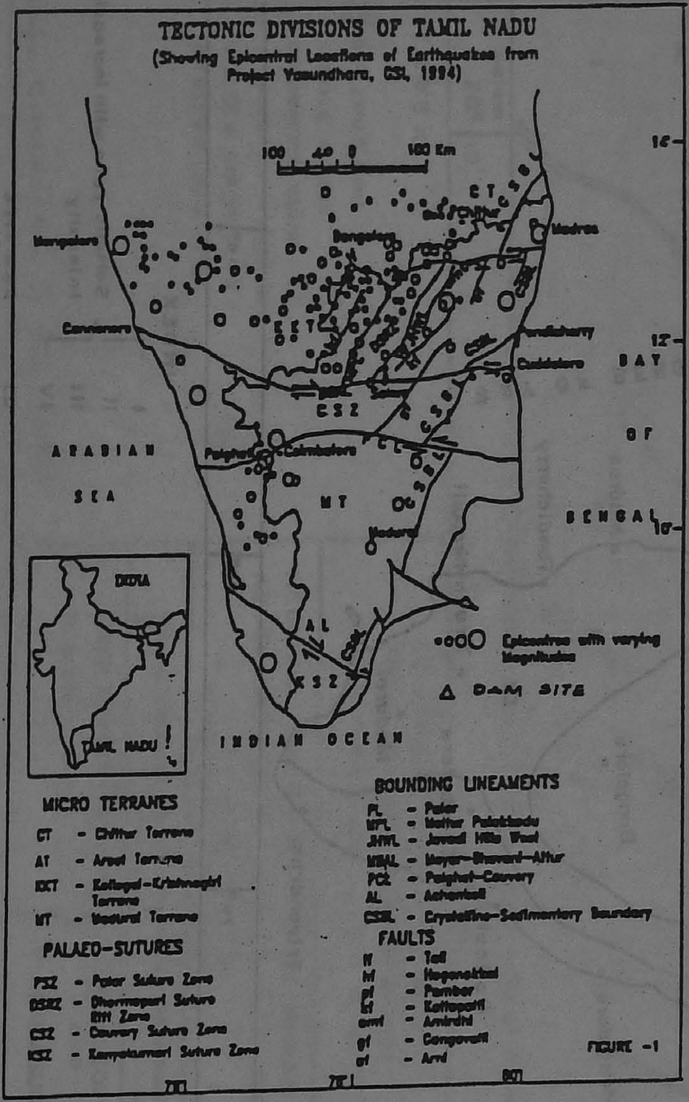


Ref: Compiled G.S.I. map

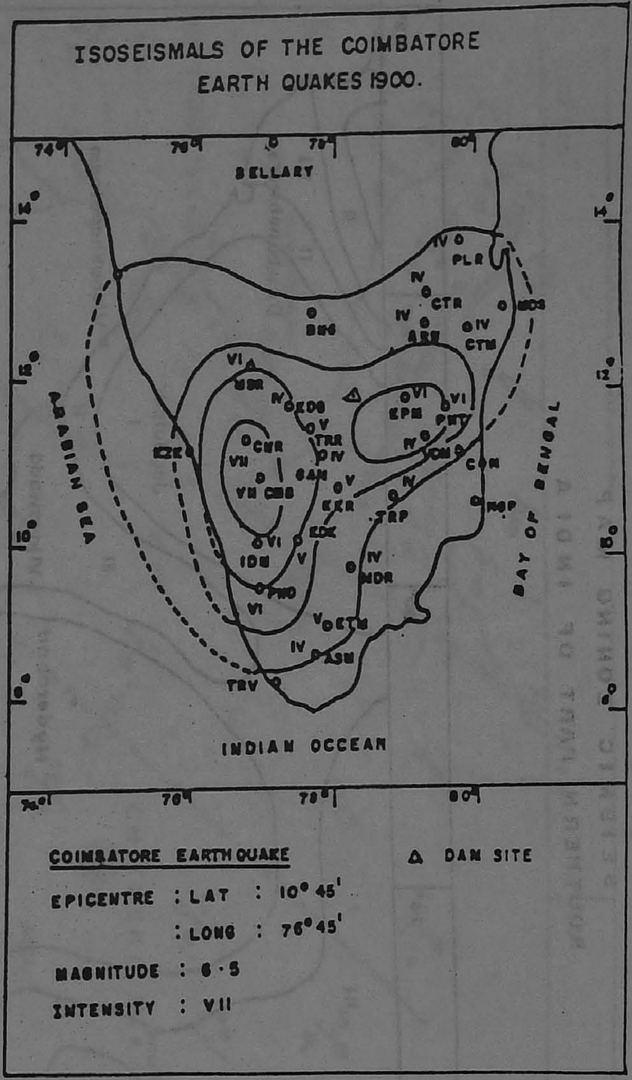
SEISMIC ZONING MAP
SOUTHERN PART OF INDIA



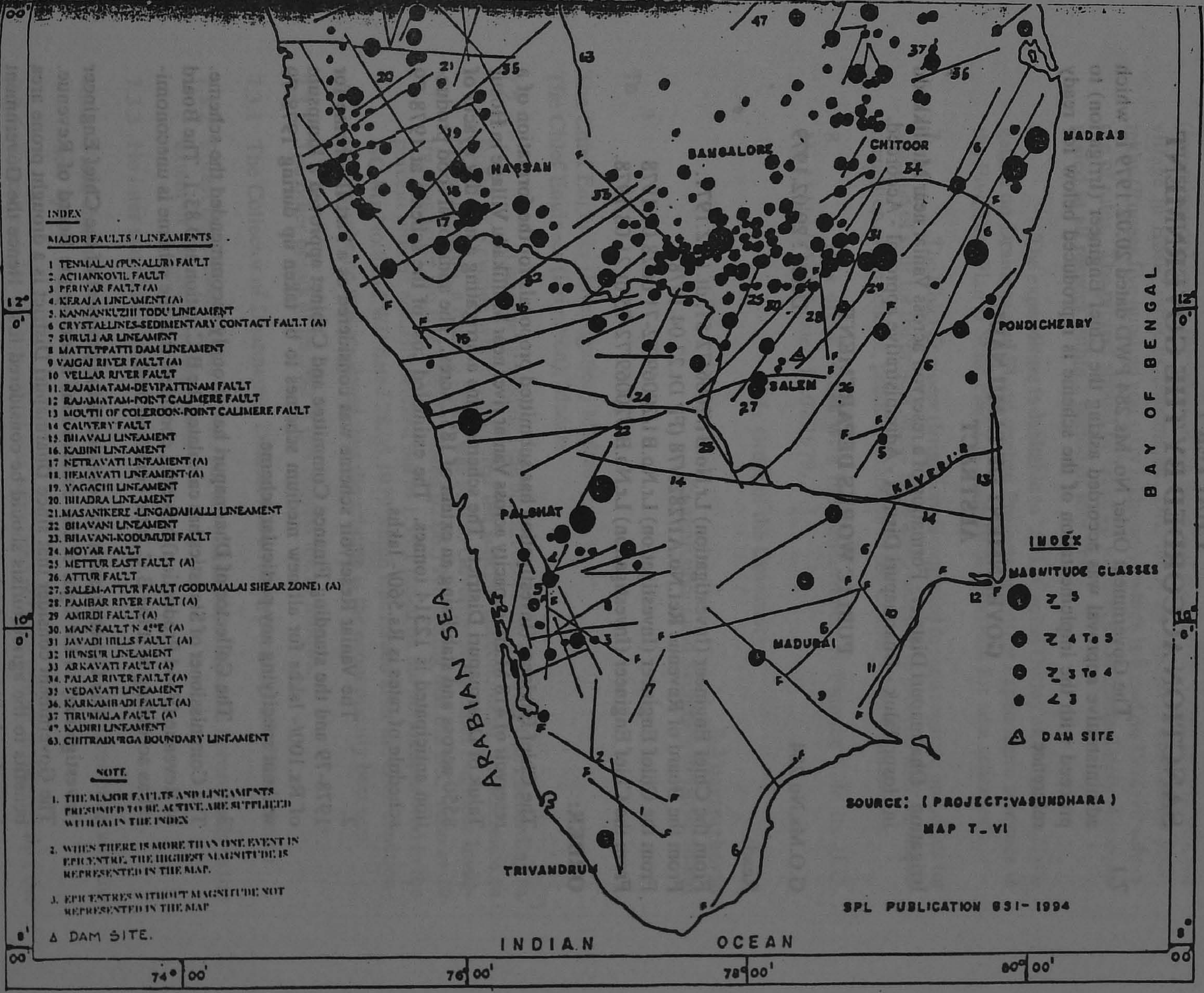
ISI CODE NO. IS : 1893-1984.



AFTER K. GOPALAKRISHNAN, 1996.



AFTER K. L. BASU 1964.



BAY OF BENGAL
ARABIAN SEA
INDIAN OCEAN
MADRAS
CHITOOR
BANGALORE
HASSAN
PONDICHERRY
SALEM
PALGHAT
MADURAI
TRIVANDRUM
KAVERI R
INDEX
MAJOR FAULTS / LINEAMENTS
1 TENMALAI (PUNALUR) FAULT
2. ACHANKOVIL FAULT
3 PERIYAR FAULT (A)
4. KERALA LINEAMENT (A)
5. KANNANKUZHI TODU LINEAMENT
6 CRYSTALLINES-SEDIMENTARY CONTACT FAULT (A)
7 SURULIAR LINEAMENT
8 MATTUPATTI DAM LINEAMENT
9 VAIGAI RIVER FAULT (A)
10 VELLAR RIVER FAULT
11. RAJAMATAM-DEVIPATTINAM FAULT
12 RAJAMATAM-POINT CALIMERE FAULT
13 MOUTH OF COLEROON-POINT CALIMERE FAULT
14 CAUVERY FAULT
15. BHAVALI LINEAMENT
16. KABINI LINEAMENT
17 NETRAVATI LINEAMENT (A)
18. HEMAVATI LINEAMENT (A)
19. YAGACHI LINEAMENT
20. BHADRA LINEAMENT
21. MASANIKERE -LINGADAHALLI LINEAMENT
22 BHAVANI LINEAMENT
23. BHAVANI-KODUMUDI FAULT
24. MOYAR FAULT
25 METTUR EAST FAULT (A)
26. ATTUR FAULT
27. SALEM-ATTUR FAULT (GODUMALAI SHEAR ZONE) (A)
28. PAMBAR RIVER FAULT (A)
29 AMIRDI FAULT (A)
30. MAIN FAULT N 45°E (A)
31 JAVADI HILLS FAULT (A)
32 HUNSUR LINEAMENT
33 ARKAVATI FAULT (A)
34. PALAR RIVER FAULT (A)
35 VEDAVATI LINEAMENT
36. KARKAMBADI FAULT (A)
37 TIRUMALA FAULT (A)
47. KADIRI LINEAMENT
63. CHITRADURGA BOUNDARY LINEAMENT
NOTE
1. THE MAJOR FAULTS AND LINEAMENTS PRESUMED TO BE ACTIVE ARE SUFFIXED WITH (A) IN THE INDEX
2. WHEN THERE IS MORE THAN ONE EVENT IN EPICENTRE, THE HIGHEST MAGNITUDE IS REPRESENTED IN THE MAP.
3. EPICENTRES WITHOUT MAGNITUDE NOT REPRESENTED IN THE MAP
Δ DAM SITE.
INDEX
MAGNITUDE CLASSES
≥ 5
≥ 4 To 5
≥ 3 To 4
< 3
DAM SITE
SOURCE: (PROJECT:VASUNDHARA)
MAP T_VI
SPL PUBLICATION 031- 1994
74° 00'
76° 00'
78° 00'
80° 00'
12° 0'
10° 0'
8° 00

CHAPTER 7

SANCTION ACCORDED BY THE GOVERNMENT

7.1 The Government Order No. Ms.284 PWD dated 20.02.1979 in which administrative approval was accorded asking the Chief Engineer (Irrigation) to proceed with the implementation of the scheme is reproduced below for ready reference :

GOVERNMENT OF TAMILNADU
ABSTRACT

Irrigation - Dharmapuri District - Formation of a reservoir across Vaniar near Mullikkadu in Hosur Taluk - Dharmapuri District - Administrative approval - Accorded.

PUBLIC WORKS DEPARTMENT

G.O.Ms.No.284 Dated : 20.02.1979

Read:

From the Chief Engineer (Investigation) Lr.No.B1/2006/72-51, dt.12.2.1971.
From the Board of Revenue Ref.No.A1/2825/78 (FP Dt.27.04.1978).
From the Chief Engineer (Investigation) Lr.No.B1/20069/72-71 dt.28.07.1978
From the Chief Engineer (Investigation) Lr.No.B1/20069/72-75 dt.21.08.1978.

ORDER:

The Chief Engineer (Investigation has submitted proposals for the formation of a reservoir of 418 M.cft. capacity across Vaniar river near Mullikadu Village in Hosur Taluk of Dharmapuri District. The scheme aims at irrigating a new dry ayacut of 8550 across and stabilising an extent of 1852 acres. The additional food production anticipated is 12314 tonnes. The estimated cost of the scheme at 1978-79 schedule of rates is Rs.560/- lakhs.

2. The Vaniar Reservoir scheme was considered as a Part II scheme for 1978-79 and the standing Finance Committee and Cabinet approved a lumpsum of Rs.100/- lakhs for all new medium schemes to be taken up during 1978-79 without specifying any particular scheme.

3. The Collector of Dharmapuri has strongly recommended the scheme. The Commissioner of Statistics has calculated the B.C. ration as 0.83:1. The Board of Revenue (Food Production) however, considers that the scheme is uneconomical as according to it the B.C. ratio comes to 0.60:1

4. The Government have considered the proposal of the Chief Engineer (Investigation) in the light of the observations made by the Board of Revenue. The Government consider that since Dharmapuri District is a drought prone area benefits to the agriculturists should be considered first. Hence the Government have decided to accord Administrative sanction to the scheme.

5. The Government, accordingly approve the proposal of Chief Engineer (Investigation) for the formation of the Reservoir across river Vaniar near Mullikadu village in Hosur taluk of Dharmapuri District at an estimated cost of Rs.560/- lakhs (Rupees five hundred and sixty lakhs only) which is based on 1978-79 schedule of rates. The project should be taken up for execution immediately and completed in all respect within a period of four years.

6. The expenditure is debitable to "553. Capital Outlay on Irrigation Navigation on Drainage and Flood control Projects and other expenditure schemes in the Five Year Plan II State Plan J.A. Lumpsum provision for new schemes".

7. The Chief Engineer (Irrigation) is requested to send separate proposals for sanction of staff for the project work. He is also requested to proceed with the implementation of the scheme, pending clearance of the Central Water Commission.

8. This order issues with the concurrence of Finance vide its U.O. No.1131A/PW/79 dated 17.02.1979.

(By Order of the Governor)

B.Vijayaraghavan
Commissioner and Secretary to Government

To

The Chief Engineer (Investigation) Madras
The Chief Engineer (Irrigation), Madras.

7.2 It was mentioned that the benefit cost ratio was only 0.6:1 according to Board of Revenue which considered the scheme uneconomical. In deference to this contention, a revised report was sent to Government in Chief Engineer Investigation letter No.B4/20069/72 dated 02.06.1976 stating that the B.C. ratio at 10 percent interest actually worked out to 1.38:1 based on the norms approved in the GO.Ms.No.826 PWD dated 28.05.1979 which was issued after the G.O. sanctioning the scheme was reviewed thus the scheme is the economically best one.

7.3 The other points of interest in this context are as follows:

7.3.1 The Collector of Dharmapuri District had strongly recommended the scheme.

7.3.2 Forest Department's concurrence for the utilisation of Reserve Forest lands to the extent of 131.56 acres was awaited.

7.3.3 No inter-state interests are involved.

7.3.4 Field channels will be executed at Government cost upto 25 acres blocks in the new ayacut area.

7.3.5 State Agricultural Department was associated with the project in determining the soil suitably and cropping pattern.

7.3.6 Betterment levy is proposed at Rs.50/- per acre for new ayacut and Rs.200/- per acre for stabilization extent. A provision of Rs.100 per acre is included in the scheme estimate for drainage in the new areas proposed to be brought under cultivation. It is however, remarked that the terrain and soil conditions do not warrant special or exclusive measures for drainage.

7.3.7 PROGRAMME OF WORK OUTLINED

The whole work was programmed to be completed in 4 (Four) years. In the first year detailed investigation wherever required, site surveys for cross masonry works, forming roads, camps and buildings, clearing the dam site, excavation of cut-off trenches, key trenches, formation of filter, etc. would be taken up. During the second year construction of regulator upto deck bridge level formation of bund and canals excavation in the first reaches were programmed to be completed. During the third year the remaining portion of the regulator, surplus course, canals, head sluices in the second reaches upstream revetment for the earthen embankment would be taken up and completed. During the fourth year, the balance items in the head works (parapets, approaches to canals, head sluices, B:T. road on top of dam etc.) would be completed. Finalisation of accounts history writing etc. would be attended to simultaneously. The entire ayacut would be brought under irrigation at the end of the fourth year.

7.3.8 ESTABLISHMENT

Originally it was proposed that 3 (three) new divisions with 15 subdivisions would be necessary for execution of the project works as per programme drawn up above. But actually two divisions, one for head works and the other for canal's only were sanctioned. The percentage of return on direct charges with and without betterment levy worked out 0.448 percent and 0.303 percent respectively.

CHAPTER 8
LAND ACQUISITION

8.1 GENERAL

The first major step in the implementation of a storage scheme is acquisition of lands. The areas necessary for the water spread and for constructing the various components of the reservoir, like earth dam, surplus regulator, surplus course and tower head sluices and canals for irrigation are worked out from the detailed drawings prepared for the various works and layouts and contour maps after the alignment of the dam line is finally fixed. This practice was systematically followed in the case of Vaniar Dam. Usually a large chunk goes for thee water spread. The next in the order is the embankment which comprises the tower head sluices and surplus regulator. In most cases the surplus arrangements are built across the river and hence the need for acquiring land specifically for the surplus course does not arise. For technical reasons, the surplus regulator had to be located at the left flank in Vaniar Dam and therefore a new surplus course for over a mile long had to be excavated. Space on either side of this new course was found necessary for depositing the excavated soil and forming protective bunds. A magazine store for safe custody and controlled distribution of explosives had to be established at this dam site. The surroundings of this explosive store with a radius of 129 metres was to be maintained as a restricted area. Working space requirements, reserve and borrow areas for maintenance purposes and taking earth respectively and approaches circumventing the hillock coming in the wayof the dam alignment absorbed considerable space. For these reasons, larger areas for these two items - viz., working space and surplus course were acquired than that required for water spread in the case of Vaniar Head works. In all, an extent of 338.68 ha. (836.54 acres) were acquired which constituted 9.8% of the total area which received irrigation benefits. This appears to be slightly high compared to the normal ratio in this regard.

8.2 The legal procedures for land acquisition are time consuming measures. Fortunately the provision that private lands can be provisionally taken over and entered upon on taking consent in writing from the rightful owners gives the much needed relief. This provision was effectively made use of by the project engineers on a number of occasions when works were to be started at short notice. Has this not been done, the head works would not have been completed in 5½ years time. Prior to the ceremonious commencement of the dam works in September, 1979 when approach routes had to be formed and the land where the embankment was to be put up had to be levelled and made ready very urgently for the function the Junior Engineers reportedly went a little out of the way in entertaining and cajoling the land owners before taking their consent. Such enthusiastic initiatives on the part of the young engineers of the project were indirectly encouraged since positive results were being achieved.

8.3 Over confidence lands one in trouble. And an incident narrated by a bold and efficient Junior Engineer of a Head works section to the writer points out how true is this old saying. After waiting for some time for the crops to be harvested by the owner of a land which was already agreed to be taken over by the

Department, he sent out a threat to the effect that if the harvesting was not done with in 48 hours or so the crops would be removed with police protection. The land lady who had not received the compensation claims for the standing crops, got enraged and sent a gang with light arms to accost the Junior Engineer. The ruffians went to the office and accosted the Junior Engineer who happened to be alone and started shouting at him. The Junior Engineer quickly perceived his helplessness and managed to escape the assault with a formal apology. He later said that he learned a lesson that delicate issues like land alienations are better handled with caution and circumspection.

8.4 By and large the land acquisition was completed peacefully and fairly expeditiously. Possession of lands belonging to the Forest Department in the water spread area was however a different story. It is dealt with in the second half of this chapter. In the scheme estimate submitted to the Government a total of 150.61 ha. (372 acres) only were originally proposed to be acquired for Head Works. The details were as follows. Land acquisition proposed in the scheme (Head works only).

Sl. No.		Patta Acres	Poromboke Acres	Reserved Forest	Total Area Acres
1.	Water Spread	123	16	131	270
2.	Bund	12	2	1	15
3.	Surplus work	33			33
4.	Campus and Buildings	54			54
				Total	372 Acres

8.5. REQUIREMENTS(EXCEEDED SCHEME PROVISION)

The areas of various categories of lands which were actually acquired were as follows:

8.5.1 FOR HEAD WORKS

Sl. No.	Purpose (Components)	Patta (Acres)	Poromboke Forest Area (Acres)	Reserved (Acres)	Total
1.	Water Spread Area	73.48	50.90	131.56	255.94
2.	Bund and Spillway	42.19	10.30	-	52.49
3.	Surplus Course	58.45	11.82	-	70.27
4.	Working space (including approaches & reserve space for magazine and borrow areas)	142.80	33.69	-	176.49
5.	Campus & Buildings	41.05	17.30	-	58.35
	Sub-Total	357.97	124.01	131.56	613.54
		(144.93ha)	(50.21ha)	(53.26ha)	(248,4ha)

8.5.2 LANDS FOR CANALS

In respect of canals the lands identified were as follows:

Dry Patta land	-	223 acres (90.28ha.)	
Sub-Total			223.00
Total			836.54
			(338.68 ha.)

The actually acquired areas for head works are far in excess of the scheme provisions. The reasons for the increase are as follows as per the letter No.211 SE/F1/D.O 2/dated 83.03.82

A river sluice was contemplated in the original scheme. The block with surplus regulator across the river covered the deep bed portion. The base for the earth dam in the rest of the alignment in the original scheme was less and bank space for earth dam accordingly worked out to be less earlier. In the revised proposal the base width where the dam height is maximum is 170 m. The length was 1360 m . The area required is 1360 x 170 = 23.12 ha.(57 acres). Hence the excess under this item. The surplus course originally was contemplated along the natural river and therefore some widening of the river margins alone was thought to be enough. Since good foundations pin river were not found feasible during detailed investigation a flank regulator and a new surplus course have been provided. The width of the new surplus course is 150 m including banks and it runs for 1250 m. Space required works out to 1250 x 150 = 18.75 ha. (46.3 acres). The area between this new course and earth dam had also to be acquired for flood protection and maintenance purpose. This area measured 23.97 acres. The total under this item is 46.3 + 23.97 = 70.27 acres. Additional quarters for TAPWEC machinery crew and engineers and construction of explosive stores with large open area around it accounted for excess under working space and campus layout and buildings.

8.5.3 The lands for the canals were spread over a number of villages located mainly in Harur Taluk of Dharmapuri District. The areas required were assessed after the condensed L.S. in respect of canals and branches was approved by Superintending Engineer and from the drawings of various components of the head works. Liberal provisions were made for the layout and the campus buildings at the dam site while arriving the total extent of land to be taken over for this project as above. The cost of lands for head works alone amounted to Rs.25.0 lakhs. The estimated amount for acquisition of lands for both the canals was Rs.20.24 lakhs. The total expenditure for the lands was therefore of the order of Rs.45.20lakhs.

8.6 REVENUE OFFICERS ASSIGNED : PROCEDURES EXPLAINED

In order to observe the legal formalities and expedite the procedures laid down in the Land Acquisition Act (I of 1894) for alienating the above lands and handing possession of them to PWD, sanction was accorded for appointing two Special Thahsildars and necessary supporting staff in March, 1980. These revenue officials commenced functioning with Head Quarters at Pappireddipatti with effect from April, 1980.

8.6.1 Briefly the various steps in acquisition of private lands are as follows:

i) Identify the lands and areas required and prepare land plan schedules from F.M. sketches, village maps and collect particulars regarding ownership etc. and forward to Revenue Department (action by PWD)

ii) Prepare draft notification under Section IV (i) of the L.A. Act. Approval by Government and publishing in Gazette and also in local news papers. (action by Revenue).

iii) Conduct enquiry under Section V (a). Deal with objection, decide the beneficiaries etc. (furnish additional details if any (action by Revenue and PWD).

iv) Send draft declaration and cost statement for approval to Government (action by Revenue)

v) Conduct enquiries under Section V(i) of the L.A. Act (action by Revenue)

vi) Publish draft declaration (Action by Revenue)

vii) Payment of compensation to rightful owners (action by Revenue)

viii) Handing over and taking possession of the lands, make entries in the register of public properties (Joint action by PWD and Revenue)

8.7 The project engineers did not loose any time in undertaking the preliminary steps envisaged in the land acquisition act for acquisition of lands. During October - November, 1979 itself, i.e. 6 months before the arrival of revenue special staff in the scene, the first batch of land plan schedules were prepared and sent to the Collector of Dharmapuri. Remarks pointed out by the Collector were attended to and additional details required by them were furnished. The stipulated enquiries under Clause 5(a) of the L.A. Act were conducted between June 1980 and October 1980 and the first set of documents in full shape for draft declaration etc. were sent to Government for approval in October, 1980.

8.8 All the formalities for alienating the required extents of lands were completed in stages according to fairly fast programmes and the documents despatched to the Government from the Collectorate at Dharmapuri in batches. Difficulties faced in this regard were discussed periodically in the District lands Plan Review meeting and amicable solution arrived at. Most of the lands were entered upon for execution of works after obtaining consent statements from the land owners in anticipation of the successful completion of the stipulated procedures under the L.A. Act. The influence of the revenue officials helped a lot in this regard.

8.9 Few land owners only refused to give consent. Necessity for taking over lands in which Mosques, Churches or Temples were situated or instances which might affect the religious feelings of the masses did not generally arise in the case of Vaniar Project. There was good co-operation among the various agencies and progress was not affected due to the legal formalities involved in the alienation of patta and poromboke lands.

8.10 TACKLING OF DIFFICULT CASES

8.10.1 Some farmers in Pappireddipatti and in the head reaches of canals were unwilling to give consent for commencing the works related to staff quarters and canals in the head reaches. One party claiming ownership of about 70 acres in the water spread area obtained an injunction restraining the PWD from proceeding with the formation of embankment in the dam site. To overcome these objections certain socially oriented respectable and influential land lords of the area were approached and were earnestly requested to prevail upon the unwilling farmers to part with the lands in question for a public welfare measure and in greater common benefits. The conciliatory approach of this nature worked. A nice compromise between individual desires and common aspirations was achieved and the PWD was able to go on with the construction of quarters in Pappireddipatti and canals in head reaches without much delay.

8.10.2 Regarding the writ petition, an effective affidavit was filed in the High Court stating that the concerned party has only partial interest in the said lands and when the majority had agreed to part with their possessions in the larger and long term public interest, the lone individual can follow suit as due compensation was promised. The writ petition was later dismissed.

8.10.3 Some ryots owning lands close to dam alignment insisted that compensation for standing crops (sugar cane) in their fields be paid promptly before they could give consent letters. The District Agricultural Officer, Dharmapuri at the instance of PWD undertook a quick and careful assessment of the crops and arrived at the amounts of compensation to be paid to the affected farmers. The amounts were disbursed and delay in the progress of works in those reaches was averted.

8.10.4 The process continued till 1986. While no difficulties of insurmountable nature were encountered in the acquisition of patta lands for Vaniar Project the case in respect of forest land was quite different.

CHAPTER 9
TRANSFER OF FOREST LAND

9.1 Because of a recent ordinance by the Centre imposting stringent conditions for preservation of all forest wealth in the country, the taking over of forest land mainly for water spread of the reservoir was met with many hurdles. In the initial stages, the Chief Conservator of Forest wrote to the Chief Engineer, PWD to shift the alignment in such a way as to avoid submersion of forest area or at any rate modify the scheme so as to scale down the requirement of reserve forest lands to a bare minimum. His argument was that the forest lands in question used to yield an annual revenue of Rs.7.84 lakhs at the rate of Rs.7,750 per hectare. Since India's forest coverage was already low any attempt to reduce it further could be permitted only in extreme cases after obtaining the permission from Government of India. Later a condition to the effect that for every extent of Reserve Forest land taken over for other purposes twice that extent of non-forest land elsewhere - preferably contiguous to the reserved forest boundary - should be placed at the disposal of forest department, besides paying compensation for loss of revenue and meeting the full cost of afforestation of the new lands (twice the area) given to them was imposed.

9.2 Against this uncompromising attitude on the part of Forest Department, the Chief Engineer, PWD had to forcibly defend the case for irrigation. Extracts of his letter sent to the Commissioner Secretary, PWD in this context are given below:

"Rs.7.34 lakhs annual revenue loss refers to the transfer of 94.74 hectares; Now the requirement has been scale down to 53.24 hectares which would involve a loss of Rs.4.13 lakhs only per year. The Forest Department has to theoretically receive an annual revenue of Rs.1,550 crores from 20,01,00 ha. reserve forest under its control in the state at the above rate of Rs.7750/- per ha. This is not actually the case. Hence there are definite constraints in the realisation. If it had been really so, it can be taken that there is force in their arguments to shift the alignment of the dam. On the other hand the alteration in the dam location will result in the acquisition of poor farmers lands. They loose their life's possession. Though they get compensation, their real life problems and difficulties continue to haunt them. The plight of these farmers so deprived is identical to that of URIAH when the Chief Conservator of the Forest has now taken the role of King David".

Continuing his strong defence, the then Chief Engineer, Investigation Thiru B.A. Jayapalan pleaded for an integrated approach for the development of the region. It was pointed out that proposals for forest improvement involved felling down of full grown trees and hauling them down to loading centres over raw ground resulting in soil erosions. The formation of the reservoir on the periphery of the reserve forest can provide transport facilities for forest produce without the above disabilities. The reservoir in the fringe area will be a source for migrating birds and animals which will in turn attract tourists. With the advent of Vaniar scheme a modern campus with communication facilities will get established close to forest limits. This development will be a definite advantage to forest staff especially the sub-ordinates and touring officers of that department.

As per the financial benefits it was already established that on the commissioning of the Vaniar Scheme an additional revenue of Rs.82.24 lakhs would accrue according to the revised norms of the Government against the reported loss of Rs.7.34 lakhs by the forest department. Taking an overall view the balance tiltes heavily in favour of a storage reservoir at this location.

In the last para of the letter, the Chief Engineer Investigation wanted the Commissioner Secretary, PWD to enlighten the Chief Conservator of Forest on the above facts that Vaniar reservoir is a catalyst for the planned development of this pocket adjoining the forest and hence he can comply with the request of PWD in the best common interest without actually communicating the contents of his letter (vide CE's letter B4/20069/72-9 dated 25.04.1979)

9.3 The earnest and persistent actions on the part of PWD led to the issue of G.O.Ms.No.994 Forest and Fisheries Department dated 14.09.1979 directing the handing over of forest land to an extent of 131.56 acres to PWD. This order perhaps just preceded the promulgation of the forest ordinance. It had therefore little credence for the future - subsequent events.

9.4 The matter dragged on for years long after the first sod of earth heralding the commencement of the works at the dam site was dug out by the then Secretary and Commissioner PWD. Thiru B.Vijayaraghan, IAS on 19.09.1979. The PWD executive staff had to be content with the permission granted and renewed on payment of rent of Rs.100 per annum for entering into forest area for survey works etc. without disturbing the forest trees. This was achieved after several meetings and discussions with the forest officials at the levels from District Forest Officer to Chief Conservator of Forest.

The extent of forest land involved was 131.56 acres and fortunately the entire area came under the water spread only. Therefore the delay did not materialy affect the progress of embankment formations and it was estimated that a quantity of 2.64 lakhs of earth would have been available in the above extent of 131.56 acres of reserve forest area. Earth was removed from other areas and the tempo of progress of earth dam was kept up.

9.5 A stage was reached in 10/82 when the soils of the required quality for the formation of embankment available in the Patta and Poromboke lands were almost exhausted in the surrounding non-forest areas. The Superintending Engineer, Projects Circle, Krishnagiri wanted that the matter be taken to the highest level through Chief Conservator of Forests by the Chief Engineer. A note was prepared by him in this context detailing the various attempts - the contacts and correspondence etc. transpired between PWD and forest officials for the transfer of Reserve Forest lands. It shows how eager and earnest the local PWD officials were in finalising the matter. This note is enclosed as Annexure to this report.

9.5 The Chief Conservator of Forest came and inspected the lands and permitted the PWD to take earth from the forest lands in anticipation of actual handing over by his department. The forest department then arranged for auction of trees.

In G.O.Ms.No.1459 Forest and Fisheries Department dated 15.12.1981 auction was permitted to be conducted for removal of the following trees in the extent of 131.56 acres of forest lands.

		Nos.
1.	Sandal Wood	3572
2.	Teak	1319
3.	Melia Dulin	18
4.	Albizzia Lebbeck	99
5.	Mango	28
6.	Neer Marudhu	50
7.	Tamarind	50
8.	Ailanthur Excelse	21
9.	Cryrocarpus Jacguil	47

A couple of very old, tall and big forest trees known to the local public as Rama and Lakshmana were asked to be preserved.

Prompt disposal in respect of costlier species like Sandal Wood, Teak and Neer Marudhu took place. But the less valuable trees which were luckily less in numbers were not so expeditiously cut and removed. Many remained in the places till 6/1984. PWD district and regional officials kept on reminding their counterparts of the forest departments periodically. Though water was stored some times upto FRL in the reservoir later the physical transfer of forest lands in the water spread did not take place. Neither the forest department objected to impounding water upto FRL of this dam.

9.6 SURPLUS LANDS

It was later found that an extent of 118.3 acres of poromboke and patta lands acquired for Dam construction and campus in the head works site at Mullikadu were surplus and as these lands were little far away, their upkeep and maintenance were posing difficulties. The Executive Engineer VRP proposed for re-transferring these lands to the former owners. Many representations from the poor farmers and hill tribes were received for possession of these lands. Somehow these lands were not parted with. But when forest lands for other projects like Kelaverappalli Reservoir scheme in Dharmapuri District were required to be acquired the surplus lands in Vaniar Dam Site were found handy. An area of 20.46 ha. (50.44 acres) was transferred to Forest Department in lieu of half that extent given to PWD by the forest department for excavating a part of the left main canal of the Kelaverappalli scheme near Hosur through the reserve forest areas in that region. "It is an irony that after all these efforts on the part of PWD the outflow of lands were only from PWD to forest not the other way round".

The compensation paid for taking over the lands required for head works including the campus at project site alone amounted to Rs.25 (twenty five) lakhs. The estimated expenditure under this sub-head for main canal and branches was

Rs.20.2 lakhs. The Unit prices prevailed for the various categories of land in certain typical villages during 1975-76 (pre-project days) were as follows:

Sl. No.	Name of Village	Cost of Wet Land		Dry Land		Garden Land	
		High	Low	High	Low	High	Low
1.	Malaynur	5,000	5,000	4,000	1,000	9,000	2,500
2.	Pippireddipatti	-	-	7,700	500	6,100	2,000
3.	Alapuram	5,000	5,000	3,000	500	5,000	2,500
4.	Adhikarapatti	10,000	2,000	5,000	500	5,000	2,500
5.	Menasi	10,000	10,000	9,000	500	10,000	2,500
6.	Boothanatham	-	-	9,000	500	10,000	1,500
7.	Venkatasamudram	9,000	6,000	8,000	4,500	10,000	5,000
8.	Parayapatti	12,000	5,000	6,000	2,500	20,000	12,000
9.	Thenkaraikottai	7,000	5,000	5,000	1,000	15,000	10,000
10.	Gurubarahalli	10,000	7,500	5,000	1,000	7,500	6,000
11.	Naranapuram	3,000	2,500	2,500	2,000	11,000	2,000
12.	Chinnakkuppam	5,000	2,500	3,500	3,000	10,000	5,000

Vide Letter No. LD is 27489/76, dt,24,11,1976 of Thahsildar Harur addressed to Executive Engineer, PWD Investigation Division, Salem.

CHAPTER 10

ACCESS ROADS CAMPUS BUILDINGS AND LAYOUTS

10.1 Access roads and campus buildings are essential features of an irrigation project coming up in remote places. Provision to the tune of Rs.66 lakhs was made in the Vaniar Scheme estimate for this purpose under sub-head K Buildings. Priority is generally given to take up the following works before the constructions of components start at dam site. This principle was adhered to in the case of Vaniar Project also.

i) Access Roads

ii) Water proof sheds for storing cement, machinery spares.

iii) Fenced yards for mobile plant, electrical transformer and open or covered sheds for repairing and Parking mobile plants.

iv) Petrol and diesel bunk

v) Quarters for engineering and technical Staff who directly supervise works and are responsible for quality control.

vi) Quarters for certain skilled technical personnel operating crew maintenance staff and Drivers.

vii) Site offices for sections and sub-divisions head-quartered at dam site.

The reason for this arrangement is obvious. Primarily it is to reduce thee travel time to the work spots so that the crew and operating staff can spend longer hours on duty during the better (cooler) times of the day.

10.2 Later, when it was noticed that there was not enough private buildings available at Harur where two divisions and one sub-division were to be stationed and at Pappireddipatti where two sub-divisions and four sections were to function buildings to house these offices and quarters for limited staff were also proposed to be constructed at these two small towns.

10.3 Campus layout was finalised in Chief Engineer's office after obtaining and examining site survey maps with levels together with the preliminary drawings of earth dam and surplus arrangements left and right side canal head sluices and in consultation with the Government Architect's section. Plans, sections and elevations for the various quarters were based on approved norms for the categories of staff for which they are meant and designs and drawings for these buildings and site offices and rest sheds were prepared and approved at division and circle levels.

10.4 APPROACH ROADS

There were three access routes for the dam site. One cart track leading to it from Venkatasamudram is 3 km. Another cart track which led to Mullikadu a

hamlet under which limits the campus has to come up. branched off from the main road connecting Venkatasamudram and Bommidi. Its length is 5 kms and it led to the centre of dam. The third one was also a cart track leading directly from Pappireddipatti to right flank of the dam. The last two roads were improved as gravel roads. The first one was taken up first for conversion as a pucca water bound macadam (WBM) road. This work was completed by August 1980. This road was black topped subsequently. A 30 KVA power supply line is taken along this road.

10.5 QUARTERS FOR STAFF

Poromboke lands to the extent needed for a limited categories of Division Office Personnel were available at Harur. But private lands had to be acquired at Pappireddipatti for putting up staff quarters, sub-division offices and an Inspection Bangalow. Here the works were started in November, 1979. The building works in Harur and dam site were commenced in December, 1979. These quarters were ready for occupation in September, 1980. A few quarters for staff and an I.B. were built at Krishnagiri circle office campus also making use of the funds allocated for buildings under this scheme. The following is the list of buildings put up for at various places:

Sl. No.	Place	Type Buildings Rest Shed	'A'Type Twin 64^2	`B'Type Twin 85^2	`C'Type Twin 125^2	`D'Type Single 90^2	Machinery Crew line Type	Artisans Block 6Nos. in each blocks
1.	Harur	1	2	4	3	1	-	-
2.	Pappireddipatti	1	2	2	2	1	-	-
3.	VRP Dam Site	1	7	7	7	2	8	20
4.	Krishnagiri	1	1	2	1	1	-	-
					(S.E's.Qrs.)	(D.S.E. Qrs.)		

10.6 SPECIFICATIONS FOR BUILDINGS

Rest sheds at the three towns above were of permanent type with two suits and a dining hall. The quarters built at Krishnagiri were also of durable nature. The one at Dam site is of semi-permanent type with a hall and one room and toilet, an observation shed with certain architectural features were put up on a small hillock at the central portion of the earth dam.

10.7 All the other structures were of non-permanent type with two suits and a dining hall. The quarters built at Krishnagiri were also of durable nature. The one at Dam site is of semi-permanent type with a hall and one room and toilet, an observation shed with certain architectural features were put up on a small hillock at the central portion of the earth dam.

10.7 All the other structures were of non-permanent/temporary nature. They were built generally according to the guidelines issued by the Superintending Engineer in Memo No.1554/208/80 AED/dt.10.10.1980.

These instructions were issued purely with a view to keep the expenditure on these temporary constructions to the bearest minimum.

10.8 The following office and functional buildings were also put up at the dam site:

i) Large Nisssan type shed for storing cement - 2 nos.
- 90m x 3.0 m

ii) Repair Shop I - 1 No. - Partially covered at sides - high roof.

iii) Repair Shop II - cum Store Keeprs's Office - 1 No. with 4 rooms.

iv) open Shed - 2 Nos. for parking vehicles.

v) Office Block Quadrangle Type - 1 No.

vi) Division Office complex - 1 No.
to house two divisions; one sub-division and 4 sections

vii) Fenced Yards - 2 Nos.
at dam site with separate enclosures for oil store (diesel/petrol) bunk, transformer yard.

viii) Magazine Building with fence around to store explosives.

ANNEXURE

VANIAR RESERVOIR PROJECT

Inflows And Out=Flows Statement. (Theoretical)

Note: **Inflow is calculated here on the basis of Dry Damp Wet Method.**

Out-Flow is computed on the basis of crop water requirement at 28 ins less useful rainfall (over the dry ayacut)

Sl.No.	Year (Assessed)	Inflow M.Cft. (Computed)	Out-flow M.Cft.	Remarks
1.	1949	1599.95	773.96	Success
2.	1950	1801.31	705.31	"
3.	51	764.99	727.93	"
4.	52	1355.09	689.63	"
5.	53	2080.87	621.09	"
6.	1954	1487.77	563.82	Success
7.	55	1258.59	617.89	"
8.	56	1651.96	529.29	"
9.	57	1651.96	529.29	"
10.	58	1102.83	515.18	"
11.	1959	1102.83	515.18	Success
12.	1960	1677.00	601.81	"
13.	1961	1550.47	648.31	
14.	1962	1907.05	697.50	"
15.	1963	1910.24	455.90	"
16.	1964	2575.72	455.98	Success
17.	65	1140.38	632.95	"
18.	66	2854.22	388.75	"
19.	67	1667.86	483.47	"
20.	68	1017.37	676.58	"
21.	1969	1456.86	472.00	Success
22.	70	1299.80	632,73	"
23.	71	2211.02	646.43	"
24.	72	1735.93	413.69	"
25.	73	285.41	691.40	Failure
26.	1974	1138.40	617.03	Success
27.	75	858.31	625.44	"

Total Inflow **403,75.47** **Percentage of Success 96%**

Average Inflow **403,75.47** **27**

= 1495.M.Cft. per year

Maximum Inflow = 2575.72 M.Cft.

Minimum Inflow = 285.41 M.Cft.

Note: These are all theoretical projections as explained above.

Sd/R.Jeyakumar, Dt.31.8.77
Asst. Engineer, PWD
P.I. Sub-Divn.II
Salem - 4.

Sd/K.R.Somasundaram
Asst. Engineer, PWD
P.I. Sub-Divn.II
Salem - 4.

Report on benefit cost ratio relating to the formation of a reservoir across Vaniar near Mullikadu Village in Harur Taluk of Dharmapuri District.

1)	Extent of new ayacut (Dry) that would be benefited.	7330 acres
2)	Extent of area that would be stabilised.	1852 acres
3)	Additional food production on 0.8 tonne per acre for new ayacut (Dry) for item 1 above.	5864.0 tonnes
4)	Additional food production at 0.5 tonne per acre in terms of rice for stablished area for item 2 above.	926.0 tonnes
5)	Estimated value of additional food production at Rs.976.20 per tonne of millets (Farm prices of millets for 1976-77 in Krishnagiri taluk) for item 3 above.	Rs.
6)	Estimated value of additional food production at Rs.1817.50 per tonne of rice based on the farm prices prevailed during 1976-77 in Krishnagiri Taluk for item 4 above.	Rs.16.83 lakhs
7)	Total value of additional food production (i.e. items 5+6 above)	Rs. lakhs
8)	Loss of food production due to acquisition of dry lands to an extent of 274.44 acres at 0.25 tonne as per scheme report.	68.61 tonnes.
9)	Value of loss of rood production at Rs.976.20 per tonne of millets (Farm prices) for item 8 above.	Rs. lakhs
10)	Deduct cost of cultivation at Rs.150/- per for 7330 acres of new area as per scheme report.	Rs.10.99 lakhs
11)	Net value of additional food production (i.e. item 7 minus item 9 and 10 above)	Rs. lakhs
12)	Cost of the scheme	Rs.540.00 lakhs

		at 5% rate of interest	at 10% rate of interest
		Rupees in lakhs	
13.	a) Interest on capital cost of the scheme	27.00	54.00
	b) Depreciation at 2%	10.80	10.80
	c) Administrative expenses at Rs.10/- per acre for 7330 acres of new area.	0.73	0.73

	d) Total amount cost (i.e.items a+b+c above)	38.53	65.53
14.	Benefit cost ratio item 11a	62.41	
	item 13.d	38.53	65.53
	=	1.62:1	0.95:1
15.	Cost of the scheme with escalation charges		Rs.621.00 lakhs
16.	a) Interest on capital cost of the scheme	31.05	62.10
	b) Depreciation at 2%	12.42	12.42
	c) Administrative expenses at Rs.10/- per acre for 7330 acres of new area.	0.73	0.73
	d) Total annual cost (i.e.items a+b+c above)	44.20	75.25
17)	Benefit cost ratio item-11	62.41	62.41
	Item 16-d	44.20	75.25
		= 1.41:1	0.83:1

ANNEXURE

From To

Thiru C.G. Jayaraman,
B.E. (Hons.) M.I.E.
Executive Engineer, P.W.D.
Vaniar Reservoir Pro.Divn.
Harur.

The Superintending Engineer
Special Project Circle
Krishnagiri.

Lr.No.122SEF 47/P1/dt.09.04.80

Sir,

Sub: Irrigation-medium Scheme - Harur Taluk reservoir across Vaniar near Mullikkadu Village - Samples of sand broken stone jelly and stone for masonry work - Regarding.

A copy of test results communicated in Executive Engineer, SMR Division Lr.No.AEE(C)/7767/F90/Dt.04.03.1980 is submitted herewith. The results are analysed and a report is submitted as below.

Stone sample compression test tested in dry condition. Average stress parallel to grain 645.95 / Sq.cm. or Stone sample compression test tested 6459.5 tonnes/ ^{2} in wet condition.

Average stress parellel to grain 605.52/sq.cm. or 6055.tonnes/^{2}.

Safe compression lead an stone should be taken not more than one tenth of the loads. Safe compression stress on the stone will be 605.5 Tonnes/^{2}. The safe compression stress on RR in cm 1:3 is only 87 tonnes/^{2} as per hand books. Hence the stones are satisfactory.

2. Coarse Agrregate: Crushing value should not exceed 45% for aggregate used for concrete other than wearing surface and 30% for concrete for wearing surfaces such as run ways, roads, and pavements.

The tested sample value comes as 18% only. Hence safe as per ISI 1970.

ii. A good building stone should not absorb more than 5 percent of its weight of water after 24 hours immersion. Any stone absorbing more than 10 percent or having specific granite less than 2.5 should be rejected as Indian/Practical Civil Engineer's Hand book by P.N.Khanna. P12/30. But test for absorption of the stone of Vaniar Dam site quarry gives the results as 0.2004%. Hence satisfactory.

3. Abrasion Test on coarse aggregate:

1. For aggregates to be used in concrete for wearing surface abrasion value as per Test results comes as 15.16% where as 30% is permissible as per ISI 1970. Hence safe.

ii. For aggregate to be used in other concrete is 50% as per ISI 383 1970 where as the result comes as 15.16% for sample. Hence safe.

Fitness modulus for sand should be between 2.5 to 3 vide Reinforced concrete by K2 RAO P7 the Fitness modulus of the sand sample is 2.895 of 2.828. Hence satisfactory.

5. Specific gravity of sand has been specified to be 2.6 to 2.85 vide reinforced concrete K2 RAO P7. (The fitness modulus of the sand sample is 2.895 and 2.828) Hence satisfactory.

Specific gravity as per the tests 2.726 and 2.792, which are within the specified value. Hence satisfactory.

6. Organic Impurities: Test results are yet to be communicated. Executive Engineer SM & R Division, Madras is being reminded.

SD/
Executive Engineer: PWD
Vaniar Reservoir Project Division: HARUR

ANNEXURE
TEST RESULTS

Concrete and Soil Mechanics Research Division, Chepauk, Madras - 600 005.

Stone samples received from Assistant Executive Engineer,
Vaniar Reservoir Project, Pappireddipatti - 636 905. Harur Taluk

S.No.	Mark on the Sample	Name of the Rock	Durability Value
1.	S	Charnockite	0.4235%
2.	O	Charnockite	0.4518%

The samples have stood all the tests for masonry and concrete works and hence it is fit for constructional purposes.

Sd/- Executive Engineer, PWD.

PUBLIC WORKS DEPARTMENT

From To

Thiru M.S. Ramachandra Rao, B.E.
Executive Engineer, P.W.D.
Soil Mechanics & Research Dn.
Chepauk, Madras-600 005.

The Superintending Engineer
Designs Circle,
Madras-600 005.

Letter No.SOIL/211 dated 16.07.1980

Sir,

Sub: Irrigation - Medium Schemes - Dharmapuri District - Vaniar Reservoir Schemes - In-situ permeability tests and load bearing tests - regarding.

Ref: 1. Superintending Engineer's (Designs) D.O.letter No.AEE.IV/7089-77 dated 9.6.90.

2. Executive Engineer, V.R.P. Division letter No.933M/F47/D1 dated 19.6.80.

Two load bearing tests were conducted, one at the proposed location of Right Tower Head Sluice and the other at left Tower Head Sluice at the Vaniar Reservoir Project site. On visual examination, the soil at the test depth was found to be reddish brown earth with Kankar. The ultimate bearing capacity obtained at Right Sluice is 8.5 kg/CM^2 (85.OT/M^2) and at left sluice is 9.2 kg/CM^2 (92.OT/M^2). The load rest data and the load settlement curves are furnished herewith. Undisturbed soil samples were also collected at the above locations for analysis in the Laboratory and the results will be submitted as soon as the tests are completed.

In-situ permeability tests were also conducted by T.S.Method in three locations in Right flank out of trench and in three locations in Left flank out of trench at the above reservoir site at L.S.400.0M, 520.0M, 560.0M, 1165.0M, 1265.OM and 1295.OM. The test results and the visuals classification of soil at the test depth are furnished in the table enclosed. Soil samples, wherever possible, were also collected for analysis in the Laboratory. They are being tested in the Laboratory and the results will be intimated separately.

Sd/-
Executive Engineer, P.W.D.
S.M.R.Division

Encl.: 1. Load test data for tests No.1 and 2.
2. Load settlement curve tests No.1 and 2.
3. Table (Permeability test data).

Office of the Executive Engineer, P.W.D.
Soil Mechanics and Research Division, Chepauk, Madras-5.

TABLE-I

In-situ Permeability Test Results
Vaniar Reservoir Project, Dharmapuri District

Sl.No.	Location	Ground Water Table	R.L. of test	R.L. of G.L.	Deptn. of Test		Coefficient of permeability 'K' in 10-6 cm/sec
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	L.S.400.0M	—	464.98	461.97	3.01	MReddish Brown earth with Kankar (Marrum).	361.44
2.	L.S.520.0M	—	461.26	456.36	4.9M	-do-	496.57
3.	L.S.560.0M	444.92M	450.16	444.71	5.45M	S.D.R.	5,592.53
4.	L.S.1165.0M	439.5M	449.0	438.5	10.5M	—	667.87
5.	L.S.1265.0M	—	451.0	441.0	10.0M	S.D.R.	442.46
6.	L.S.1295.0M	—	454.0	448.5	5.56M	"	5,083.76

Sd/-
Executive Engineer, P.W.D.
S.M.R. Division.

Name of Scheme: **Vaniar Reservoir Project**
Dharmapuri Dist.-Left Tower Head Sluice

Date of Test: 05.07.80
Nature of soil: Reddish brown earch with Kankar

R.L. of Test:Pi 450.28
L.S. 735.0

Size of Plate : 40 cm x 40cm
Least count of Dial gauge: 0.01mm.

Load Test No.1

Load (kg)	1000	2000	3000	4000	5000	6000	8000	10000	12000	14000	16000	18000	Remarks
Pressure (Kg/C²	0.625	1.25	1.875	2.5	3.125	3.75	5.0	6.25	7.5	8.75	10.0	11.25	
Time mts.		Dial Gauge Reading:							Initial Reading of Dial Gauge:20-58				
0	20-34	20-00	19-67	19-35	18.86	18.42	17-65	16.89	16-14	15.35	14-44	13-43	Ultimate
1	-32	19-96	-63	-30	-78	-35	-57	-81	-06	-29	-33	-35	Bearing
4	-27	-93	-60	-28	-73	-32	-51	-77	15-98	-22	-26	-27	Capacity
10	-26	-90	-58	-25	-71	-29	-47	-74	-93	-16	-22	-22	= 9.2 Kg/Cm²
20	20-26	-88	19-57	19-23	18-70	-25	-45	-72	-89	-12	-18	-18	or 92.0 T/m²
40	-	-	-	-	-	18-23	17-44	16-72	15-87	15-08	-14	-25	
60	-	-	-	-	-	-	-	-	-	-	14-11	13-12	
Total Settle-ment (in mm)		0.32	0.70	1.01	1.35	1.88	2.35	3.14	3.86	4.71	5.5	6.47	7.46

Sd/-
Executive Engineer, P.W.D.
S.M. & R.Divn. Madras-5.

Name of Scheme: **Vaniar Reservoir Project**
Dharmapuri Dist.-Left Tower Head Sluice

Date of Test: 07.07.80
Nature of soil: Reddish brown earch with Kankar

R.L. of Test:Pi 450.20
L.S. 131.0

Size of Plate : 40 cm x 40cm
Least count of Dial gauge: 0.01mm.

Load Test No.2

Load (kg)	1000	2000	3000	4000	6000	9000	12000	14000	16000		Remarks
Pressure (Kg/Cm²	0.625	1.25	1.875	2.5	3.75	5.625	7.5	8.75	10.0		
Time mts.	Dial Gauge Reading:							Initial Reading of Dial Gauge:20-58			
0	18-08	17-74	17-50	17-29	16.98	16.04	15-30	14.53	13-70		Ultimate
1	-06	-72	-48	-27	-80	15-99	-25	-47	-62		Bearing
4	-05	-71	-47	-26	-75	-93	-19	-41	-56		Capacity
10	-04	-70	17-46	-25	-72	-89	-15	-37	-52		= 8.5 Kg/Cm²
20	18-04	17-69	-	12-68	-70	-86	-12	-34	-49		or 85.0 T/m²
40	-	-	-	-	16-68	15-84	-10	-32	-46		
60	-	-	-	-	-	-	15-09	14-31	13-44		
Total Settlement (in mm)		0.26	0.61	0.84	1.06	1.62	2.46	3.21	3.99	4.86	

Sd/-
Executive Engineer, P.W.D.
S.M. & R.Divn. Madras-5.

OFFICE OF THE EXECUTIVE ENGINEER, PWD
SOIL MECHANIC AND RESEARCH DIVISION, CHEPAUK, MADRAS-5

Stone Samples: received from Assistant Executive Engineer, Vaniar Reservoir Project. Pappireddipatti, Harur Taluk.

COMPRESSION TEST: TESTED IN DRY CONDITION

Sl. No.	Mark on Specimen	size of Specimen	Area in sq. inch.	LOAD		STRESS	
				LBs.	Kg.	PSI	Kg/Sq. cm
1.	2	3	4	5	6	7	8
1.	0	2"x2"x2"	4	47500	21546.84	11875	834.90
2.	0	"	4	42500	19278.75	10625	747.01
3.	0	"	4	46000	20866.41	11500	808.53
4.	0	"	4	34000	15423	8500	597.61
5.	0	"	4	37500	17010.66	9375	659.13

Average stress in perpendicular to grain = 821.72 Kg/sq.c^2
Average stress parallel to grain = 703.07 - do -

OFFICE OF THE EXECUTIVE ENGINEER, P.W.D.
SOIL MECHANIC AND RESEARCH DIVISION, CHEPAUK, MADRAS-5.

Stones samples received from Assistant Executive Engineer, Vaniar Reservoir Project Division, Pappireddipatti, Harur Taluk.

Compression Test: Tested in Wet Condition:

Sl. No.	Mark on Specimen	size of Specimen	Area in sq. inch.	LOAD LBs.	Kg.	STRESS PSI	Kg/Sq. cm
1.	2	3	4	5	6	7	8
1.	0	2"x2"x2"	4	*41500	18825.13	10375	729.44
2.	0	"	4	41200	18689.05	10300	724.16
3.	0	"	4	41500	18825.13	10375	729.44
4.	0	"	4	**35300	16012.70	8825	620.46
5.	0	"	4	34000	15423.00	8500	597.61

*Perpendicular to grain
**Parallel to grain

Average stress in perpendicular to grain = 727.68 kg/C²
Average stress in parallel go grain = 609.04 - do -

OFFICE OF THE EXECUTIVE ENGINEER, P.W.D.

Soil Mechanics and Research Division, Chepauk, Madras-5

TEST REPORT

Source: Executive Engineer, PWD, Vaniar Reservoir Project Division, Harur Dharmapuri District.

Ref: Letter No.34/80/SRPI/F9/dated 22.01.80

Sample: Sand Samples

Sieve	Analysis/ Sieve Designation	Meenar River Sand		Vaniar River Sand	
		Percentage Retained	Comulative Percentage Retained	Percentage Retained	Comulative Percentage Retained
1.	4.75	2.2	2.2	1.9	1.9
	2.36	6.2	8.4	4.7	6.6
	1.18	18.2	26.6	15.7	22.3
	600 Micron	36.2	62.8	38.7	61.0
	300	26.7	89.5	30.0	91.0
	150	10.5	100.0	9.0	100.0
2.	Fineness Moldulus		2.895		2.828
3.	Specific gravity		2.726		2.732
4.	Bulk Density Compacted		1695.531 Kgm per cu-metre		1678.295 Kgms/ cu-metre.per
	Loose		1512.280 "		1524.527 "
5.	Organic Impurities		***		***

*** Test results will be sent as soon as results are available.

ANNEXURE

Copy of letter No.R.Dis.5789/74 dated 31.12.74. from the District Agricultural Officer, Krishnagiri addressed to the Collector, Dharmapuri District.

Sub: Irrigation - Dharmapuri District - Harur Taluk - Forming a reservoir in Vaniar near Mullikadu Village - quality of soil of the land for wet cultivation - report submitted.

Ref: Collector's No.Roc.5461/73, dt.25.02.74.

As per the reference cited above, I have inspected the site proposed for the construction of a reservoir across Vaniar near Mullikadu Village and ayacut areas. The ayacut areas lies in the village of Venkatasamudram, Alapuram, Molayanur, Kolimakanur and Pappireddipatti villages. Under the proposed ayacut, an area of 1318 acres are getting water from Vaniar through tanks and check dams and wet crops are being cultivated. The stand of the paddy crop in the existing wet lands are very good as the soil is very fertile. By constructing the proposed dam apart from the existing wet lands which can let assured water supply, the dry and garden lands on both sides of the Vaniar river can be brought under cultivation. Even in the dry lands, the crops have cultivated paddy, tapioca and millet crops under wet irrigation. Here also the stand of the crops are good. By construction of the dam these area can also get assured water supply and two crops of paddy can be cultivated.

The soil on both sides of the river are fertile and depth is varying two feet to four feet. The soil is red loam and paddy, sugarcane and Babana cultivation apart from millets can be cultivated and will give good yields. There is no alkaline patch in the area and as such any how the soil is quite suitable for wet cultivation and high yielding varieties of crops can be extended in the whole ayacut area proposed.

Sd/- V.R.Sellanna Gounder
District Agricultural Officer,
Krishnagiri

/ True Copy/

ANNEXURE

Copy of the Chief Engineer (Irrigation), Chepauk, Madras-5 Memo.No.B4/20069/72-42/dated 20.07.77 to the Superintending Engineer, PWD Investigation Circle, Tiruchi.

Sub: Irrigation-Medium Scheme-Dharmapuri District-Vaniar Reservoir Scheme near Mullikadu Village in Harur Taluk - Detailed plans and estimate - Returned with remarks.

Ref: S.E., invn.Circle's Lr.No.82CE/F.119/D3/dt.01.04.77.

The detailed plans and estimates submitted by the Superintending Engineer, Investigation Circle, Tiruchi is returned with the following remarks,

2. The detailed estimate has not been accompanied by the questionnaire duly answered as prescribed by the Chief Engineer (Investigation).

3. The designs adopted for earth bund and other structures, designs circle has not been consulted.

4. Working table: For the stabilisation ayacuts, water requirements worked out as 60" and this is incorrect. The figure adopted is for new wet lands. Hence the working table may be revised suitably.

5. Surplus course: The length and the cost of the surplus course may be reduced if an alternate site for surplus regulator is proposed (as per page 7 of the Superintending Engineer's report).

6. It is seen from the L.S. of earth dam, trial pits have been excavated. But there is no mention in the report whether any bore holes have been made to study the substrata at the proposed site for necessary structures.

7. The availability of suitable soil for casing and hearing zone in the near by area, is not clearly stated in the report. The local soils may be sent to SM & R and as for test to ascertain its suitability.

8. Hydrology: As per approved hydrology there is a surplus of 2945 Mcft. of water is available at the tail end of the river and the following 5 schemes were already formulated and sent to Government:

1.	Kelavarapalli Scheme	962 Mcft.
2.	Thumbalahalli Scheme	262 Mcft.
3.	Pambar Scheme	420 Mcft.
4.	Andiappanur Odai Scheme	175 Mcft.
5.	Sathanur right side channel	2200 Mcft.
	Total	**4019 Mcft.**

Now by Vaniar Scheme 418 Mcft. of water is proposed to be stored and this needs detailed study of the hydrology.

9. For Yercaud Rainfall station, an yield of 27 Mcft/sq.miles is adopted. The authority for the approval of the same has not been mentioned.

10. It is noted from the Ponniar hydrology that there are three anicuts across the river Vaniar and the first one is Venkatasamudram anicut which is situated just below the proposed reservoir site and the details of observed flows at this anicut may be furnished.

11. In addition, the following differences between P.R. and D.E. is observed requires clarification.

S.No.	Particulars	P.R.Est.	Detailed Est.
1.	New dry lands proposed	11654	8890
2.	Existing lands proposed	2406	1852
3.	Capacity	506	418
4.	Yield for Yercaud R.F.Station per sq.mile	37	27
5.	To dispose max.flood	High coefficient is proposed	Regulator is proposed.

12. While calculating the B.C. ratio a rate of Rs.2000/- is taken for the yield from wet (stab) lands. As a policy, we are adopting a uniform rate of Rs.2500/- in all our scheme estimate.

13. For acquiring forest lands, the rate should be approved by Forest Department and the concurrence for the acquisition should also be obtained and sent.

14. While calculating the escalation cost, latest procedures must be followed.

The Superintending Engineer is requested to attend all the above remarks and resubmit the same very early.

B.A. Jeyapalan,
Chief Engineer (Investigation).

Encl.:-

1. Estimate for Headworks.
2. Estimate for canals.
3. Design calculations and ayacut statement.
4. Working table.
5. Original plan volume for Headworks and C.S. works.
6. Original plan volume for L.S. canal.
7. Original plan volume for R.S. canal.

/ true copy /

ANNEXURE

PUBLIC WORKS DEPARTMENT

From	To
Thiru K.S.Kunjithapatham, B.E., Executive Engineer, P.W.D., Project Investigation Division, Salem - 636 004.	The Chief Engineer (Investigation), P.W.D., Chepauk, Madras - 600 005.

No. 31 CE/D3/77/F 97, dated 06.09.77.

Sir,

Sub: Irrigation - Medium Scheme - Dharmapuri District, Harur Taluk - Vaniar Reservoir Scheme near Mullikadu Village - Detailed Plans and Estimates - Resubmission of - Reg.

Ref: Chief Engineer (Investigation)'s Memo No.B4/20069/72-92/dated 20.07.77.

I herewith resubmit the detailed plans and estimate for the formation of a reservoir across Vaniar River near Mullikadu Village in Harur Taluk after attending to the Chief Engineer (Investigation)'s remarks pointed out in Chief Engineer's Memo cited.

The reply to the Chief Engineer's remarks is submitted as follows:

2. Necessary questionaire duly answered as prescribed by the Chief Engineer (Investigation) has been prepared and appended in the report.

3. The earth dam sections have been adopted based on the latest typical sections of Adavinarkoil Reservoir Scheme with a free board of 2 M. in consultation with the Superintending Engineer (Designs). Necessary field particulars have been submitted to the Superintending Engineer, Designs Circle, Madras-5 for furnishing designs and drawings for the surplus regulator, river sluice and head sluice. The drawings for the above structures are awaited. However the estimates for the above works have been prepared finishing the designs in this office.

4. The working table has been revised taking the requirement of water for stabilisation ayacut at 25 acres/M.cft. for the last two months of the crop period.

5. To study the alternate proposal for surplus regulator bore holes were drilled at L.S.1295 M. 1308 M. They were drilled upto the elevation of 438.8 M. and 437.10 M. respectively. The rock is met with in the bore hole at L.S. 1295 M. at elevation 439.80 M. (i.e. at a depth of 14 M). No rock was met with in the hole at L.S. 1308 M. even at 60 feet below ground level. Due to the reasons of the non-availability of rock at economical depths, the original proposal of left flank surplus regulator is finalised in this scheme estimate. The Superintending Engineer (Designs) Madras in Letter No.AE IV/7089/77/ dated 01.09.77.addressed to the Chief Engineer (Investigation) has also pointed out the merits and demerits for both the proposals and recommended the original proposal of having the surplus regulator in the left flank itself.

6. The details of the substracts based on the trial pits excavated and the observations made in the nearby wells have since been mentioned in the scheme report.

7. The necessary soil samples taken from the trial pits excavated in the water spread area have been sent to the Executive Engineer, S.M. & R Division, Madras-5 for test. The availability of suitable soil for casing and heating zone will be assessed on receipt of the test results from the Executive Engineer, S.M. & R Division.

8. This Scheme is being proposed taking into consideration of the availability of the yield in Vaniar Minor Basin before its confluence with Ponniar River. The yield at the proposed dam site is arrived at based on dependable yield for Yercaud Rainfall Station worked out by Dry-Damp-Wet method. The available water potential at the proposed reservoir site works out to 1098 M.cft. Out of which, 836 M.Cft. of water is proposed to be utilised under this proposal including the requirement for stabilising the lower down ayacut under the existing four anicuts in the Vaniar River.

9. The detailed yield calculation for Yercaud Rainfall Station has been worked out by Dry-Damp-Wet method and adopted in this estimate for computing the availability of water. The yield calculation is submitted along with the scheme estimate and the same may please be approved since the yield calculation for Yercaud Rainfall Station was not approved so far by the competent authority.

10. As regards to the observed flow for the lower down anicuts, I submit that the readings for the surplus over the anicuts (Upstream and tail water readings) are not available for the anicuts lower down.

11. (i) As regards to the Variation in the ayacuts furnished in the preliminary report and the detailed estimate, I submit that the ayacut has been localised based on the Marking table worked out for this Scheme and taken in the detailed estimate.

11. (ii) In the preliminary report, the stabilisation ayacut under anicuts of Kallar, a tributory to Vaniar was also included. But in the detailed estimate, only the ayacut under anicuts in Vaniar River has been taken into consideration.

(iii) In preliminary report, the capacity of the reservoir was worked out based on G.I. Map contour for the F.R.L. 470.310 M. During detailed investigation, the block levels were taken and capacity worked out for the F.R.L. 471.00 M.

(iv) The yield for Yercaud Rainfall Station was arrived as 37.00 M.cft/sq.mile based on Strange's Table and the same was adopted in the preliminary report. In the detailed estimate, the yield calculation prepared based on Dry-damp-wet method was adopted. The dependable yield works out to 27.655 M.Cft./sq.mile.

(v) As per the instructions of the higher authorities during inspection of the site, the regulator is proposed to dispose off the maximum flood discharge.

12. The benefit cost ratio has been worked in the scheme as per the latest Chief Engineer (Investigation) is circular Memo No.B3/82276/76-49/dated 26.08.77.

13. The District Forest Officer, Salem has been addressed for giving concurrence for the acquisition of lands as well as for the rate for the cost of lands to be acquired. The reply from the District Forest Officer is awaited. a rate of Rs.500/- Acre has been adopted in the estimate based on the enquiry made from the authority concerned.

14. The latest procedures have since been followed while calculating the escalation cost for this scheme.

The estimate cost of the proposal works out to 539.00 lakhs. The anticipated additional food production works out to 6687 tonnes. The benefit cost ratio at 10% interest works out to 0.82:1.

Sd/- Executive Engineer, P.W.D.
Project Investigation Division
Salem - 636 004.

Enclosures:

1. Report	—	2 nos.
2. Detailed estimate	—	2 nos.
3. Design calculation and ayacut details	—	2 nos.
4. Yield calculation for Yercaud Rainfall station	—	1 no.
5. Working table	—	1 no.
6. Original Plans Volume	—	3 nos.
7. Ammonia Print Plans	—	1 no.

Copy along with the enclosures submitted to the Superintending Engineer, Investigation Circle, Trichy-20 for favour of Superintending Engineer's kind information.

Sd/-
Executive Engineer, P.W.D.
Project Investigation Division
Salem - 636 004.

Encl:

1. Report	—	1 no.
2. Detailed Estimate	—	1 no.
3. Design Calculation and ayacut details	—	1 no.
4. Yield calculation for Yercaud Rainfall station	—	1 no.
5. Working table	—	1 no.
6. Ammonia Prints Plans	—	1 no.

ANNEXURE

VANIAR RESERVOIR SCHEME

CLASSIFIED ABSTRACT FOR HEAD WORKS

Sl. No.	Sub-Head	Details of works	Total of individual works.	Total under each sub-head.
1.	2	3	4	5
1.	A.Preliminaries.	Preliminary expenses such as clearing the site, setting out alignment, surveying and levelling operation etc.	3,84,000	3,84,000
2.	B.Lands	Land Acquisition charges for Headworks, water spread area and bund.	12,20,000	12,20,000
3.	B.Works	i. Earth Dam	1,81,00,000	
		ii. Tower head sluices 2 nos at Rs.680000/- each	13,60,000	
		iii. River sluice	10,15,000	
		iv. Surplus Regulator	39,00,000	
		v. Surplus course	58,00,000	
			3,01,75,000	3,01,75,000
4.	K.Buildings	Quarters for the office Staff Project House, Store shed, Lascars shed, Machinery yard.	27,00,000	27,00,000
5.	M.Plantation	Plantation	2,00,000	2,00,000
6.	O.Miscellaneous.	i. Formation of approach road for dam site.	5,00,000	
		ii. Electrification of camps, residential buildings and dam site including transformers.	3,50,000	
		iii. Telephone connection	1,50,000	
		iv. Water supply and sanitary.	2,50,000	
		v. Educational and Medical facilities	1,50,000	
		vi. Importation of labour.	50,000	
		vii. Improvements to existing anicuts.	2,50,000	

		viii. History writing cell	30,000	
		ix. Parks and Lawns	80,000	
		x. Research expenditure	60,000	
			18,70,000	18,70,000
				3,65,49,000
7.	P.Maintenance	Maintenance of works during execution.	3,37,000	3,37,000
8.	a.Special Tools	Special Tools and Plants and Plants not exceeding 12 1/2% on works excluding 'B' lands.	44,58,000	
		Deduct 75% as resale value	33,44,000	
		Net Value	**11,14,000**	11,14,000
		Total for head works		**3,80,00,000**

(Rupees three hundred and eighty lakhs only)

MULLIKADU VANIAR RESERVOIR SCHEME

Classified Abstract for left side main canal and branches

Sl. No.	Sub-Head	Details of works	Total of individual works.	Total under each sub-head.
1.	2	3	4	5
1.	A.Preliminaries	Preliminary expenses such as clearing the site, setting out alignment, surveying and levelling operation etc.	40,000	40,000
2.	B.Lands	Land acquisition charges for canal.	6,50,000	6,50,000
3.	C.Works	i. a.D.I.Sluice 35 nos. typical estimate at L.S.3.925 km at Rs.2,600/- each 35 x 2600 = 91,000	91,000	
		b. Distributory head sluice 5 nos. typical estimate at L.S.5,450 km. at Rs.4,800/- each 4,800 x 5 = 24,000	24,000	
		ii. Tail Dam 6 nos. typical estimate at L.S.0.650 Km Branch canal II at Rs.2,000/- each 2000 x 6 = 12,000	12,000	
		iii. Lining of the main canal and branches.	15,88,000	
			17,15,000	17,15,000
4.	D.Regulator	L.S.Provision for regulator in canal.	30,000	30,000
5.	E.Falls and weirs	i. 1.00 m drop 8 Nos. Typical estimate at L.S.3.575 km at Rs.2,300/- each 2,300 x 8 = 18,4000	18,4000	
		ii. 2.0 m drop 17 nos. Typical estimate at L.S.9.775 km at Rs.2,700/- each 2,700 x 17 = 45,900	45,900	
			64,300	64,300

1.	2	3	4	5
13.	Q.Special T & P	Special Tools and plants at 12 1/2% on works.	88,300	
		Deduct 75% as resale value.	3,66,225	
			1,22,075	1,22,075
II.		Distributories (added in the main canal estimate)		
		Water course drainage works	17,125	
III.		ii. Full channel excacvation and a acquisition for field channel for 4050 ac. at Rs.100/- acre.	4,05,000	
			4,22,125	4,22,125
				51,00,000

(Rupees fifty one lakhs only)

Cost of the canal for a length of 11.40 kms. catering to 2830 acres.	Rs.51.00 lakhs
Cost of the 6 km extension of the same to irrigating an additional extent of	Rs.21.50 lakhs
	Rs.72.50 lakhs

VANIAR RESERVOIR SCHEME

CLASSIFIED ABSTRACT FOR RIGHT SIDE CANAL AND ITS BRANCHES

Sl. No.	Sub-Head	Details of works	Total of individual works.	Total under each sub-head.
1.	2	3	4	5
1.	Preliminary	Preliminaries	50,000	50,000
2.	B.Lands	Land acquisition charges for right side canal and its Branches.	7,00,000	7,00,000
3.	C.Works	i. Sluice 49 nos.		
		a. Typical section at L.S. 2.925 km. at Rs.2,600/- 49 x 2600.	1,27,400	
		b. Distributary head sluice 3 nos. typical section at L.S. 45 km at Rs.4,800/- 3x4800	14,400	
		ii. Lining for main and branches.	19,16,000	
		iii. Tail dam 4 nos. typical section at L.S.0.65 km 4 x 2000	8,000	
			20,65,800	**20,65,800**
4.	D.Regulator	Regulator (Lumpsum)	30,000	30,000
5.	E.Falls & Weirs.	i. 1.00 M drop 64 nos. typical sections at L.S.3.575 km at Rs.2300/- 4 x 2300	9,200	
		ii.2.00 M drop 9 Nos. typical sections at 9.775 km at Rs.2,700 2700 x 9.	24,300	
			33,500	**33,500**
6.	F.Cross drainage works.	i. Super passage 1 No. typical section at on at 10.825 km at Rs.10,000/- 1 x 10,000	10,000	

		ii. Under Tunnel 16 nos. typical section at L.S.5.845 km at Rs.25000/- 25,000 x 16.	4,10,000	
			4,20,000	4,20,000
6.	F.Cross drainage works.	i. Super passage - 4 nos. typical estimate at L.S.10,000/- each. 10,000 x 4 = 40,000	40,000	
		ii.Under tunnel 8 Nos. typical estimate at L.S. 5.848 km at Rs.25,000/- each 25,000 x 8 = 2,00,000	2,00,000	
		iii.Through acqueduct 2 nos. typical estimate at L.S. 4.63 km at Rs.1,00,000/- each 1,00,000 x 2 = 2,00,000	2,00,000	
		Through acqueduct 1 no. at L.S. 0/200 km lumpsum at Rs.2,00,000	2,00,000	
			6,40,000	6,40,000
7.	G.Bridges	i. Road culvert 2 nos. typical estimate at L.S.4.338 km at Rs.38,300/- each 38,300 x 2 = 76,600	76,600	
		ii. Pipe culvert 7 nos. typical estimate at L.S. 7,125 km at Rs.10,700/- each 10,700 x 7 = 74,900	74,900	
			1,51,500	1,51,000
8.	K.Buildings	Lascars quarters (Twin type) L.S.	40,000	
			40,000	40,000
9.	L.Earth work	Earth work excavation for main canal and distributaries.	11,65,000	
			11,65,000	11,65,000

10.	M.Planatation	Plantations L.S.	10,000	
			10,000	10,000
11.	O.Miscellaneous	Miscellaneous L.S.	30,000	
			30,000	30,000
12.	MP.Maintenance	Maintenance	20,000	
			20,000	20,000
13.	Bridges	i. Road culvert 3 nos. typical section at L.S.4.338 km at 38,300 x 3	1,14,900	
		ii.Pipe culvert 2 nos. typical section at L.S. 7.125 km at Rs.10,700/- 10,700 x 2	21,400	
			1,36,300	1,36,300
14.	K.Buildings	Quarters for field staff	1,00,000	1,00,000
15.	L.Earth work	Earthwork excavation for main canal and branches.	10,94,000	10,94,000
16.	M.Plantation	Plantation	20,000	20,000
17.	O.Miscellaneous	Miscellaneous	30,000	30,000
18.	P.Maintenance	Maintenance	20,000	20,000
19.	Special T & P	Special Tools and Plants at 12 1/2% on works excluding (B.Land)	5,00,000	
		Deduct 75% resale value	3,75,000	
		Net value	**1,25,000**	1,25,000
		Water course		
		i. Drainage works	25,400	
		ii.Field channel excavation and land acquisition for field channel at Rs.100/- acres for 4,500 acres. 4,500 x 100	4,50,000	
			4,75,400	4,75,400
				53,00,000

(Rupees fifty three lakhs only)

VANIAR MULLIKADU RESERVOIR SCHEME

CONDENSED CLASSIFIED ABSTRACT

Sl.No.	Details of works		Rupees in lakhs
1.	Works as per overall estimates		
	a. Head works	380.00	
	b. Left side canal	72.500	
	c. Right side canal	53.000	
	Total	505.500	505.500
2.	a) Establishment charges at 10% on works excluding 'B' lands.		47.980
	b) Project allowance at 0.5%		2.399
3.	Pensionary charges at 9.43% on establishment charges.		4.525
4.	Tolls and Plants ordinary at 1% on works.		5.055
5.	Audit and Accounts at 1% on works.		5.055
6.	Loss on stock at 0.1% on works.		0.506
7.	Receipts and Recoveries:		
	a) Deduct 75% on the provisions made towards special tools and plants.	10.208	
	b) Other Receipts	0.812	
	Total Receipts	11.020	(-)11.020
	Total cost of the project		560.000
	(Rupees five hundred and sixty lakhs only)		

MULLIKKADU VANIAR RESERVOIR SCHEME

ANTICIPATED FINAL COST OF THE SCHEME

The Scheme is estimated to cost Rs.560.00 lakhs without escalation charges based on 1978-79 schedule of rates. The whole work is programmed to be completed within 4 years. The following is the escalation statement.

Year	Allotment of fund Rupees in lakhs	Escalation cost Rupees in lakhs	Total cost Rupees in lakhs
1978-79	100.00	—	100.00
1979-80	180.00	18.00	198.00
1980-81	180.00	36.00	216.00
1981-82	100.00	30.00	130.00
Total	560.00	84.00	644.00

Cost of the Scheme with escalation charges : Rs.644 lakhs.

ANNEXURE

GOVERNMENT OF TAMILNADU

ABSTRACT

Forests - Dharmapuri District - Vaniar Reservoir Scheme near Mullikadu Village in Harur Taluk - Forest areas involved - Concurrence of Forest Department - Orders issued.

Forests and Fisheries Department

G.O.Ms.No.994, Dated: 14.09.1979.

Read:-

1. G.O.Ms.No.284, Public works Department, dt.20.02.1979.
2. From the Chief Conservator of Forests (General) D.O.Lr.No.G3/113313/77-7, dt.31.03.1979.

ORDER:

In G.O.Ms.No.284, Public Works, dated 20.02.1979 orders were issued sanctioning the Vaniar Reservoir Scheme for Rs.560/- lakhs. The Chief Engineer (Investigation) has sought for the concurrence of the Forest Department for occupation of 234.10 acres of forest land in Shevaroys North Range of Salem Division, for implementation of the above scheme. The Forest land is reported to contain considerable population of sandal and tamarin trees besides other timber and fuel trees and bamboo growth. The average revenue from the forest land has been reported to be Rs.7,34,235/-. The Chief Conservator of Forests has stressed the need to save the valuable forest from being submerged by any reservoir.

2. Though in the original proposals sent by the Chief Engineer (Investigation), the extent of forest lands liable for submersion was given as 234.10 acres, in the final proposals the extent is only 131.36 acres and the average Revenue from the land would workout to Rs.4.13 lakhs.

3. The Government have carefully examined the report of the Chief Conservator of Forests (General). The forest growth is only sandal, tamarind, bamboo and fueld species and the loss is primarily only in commercial terms. If this is to be viewed in commercial terms, then the gain in agricultural production is out of all proportion to the loss to the Forest Department. As against 132 acres that will be submerged, 8350 acres will get irrigation benefits. The additional produce for each acre is estimated at Rs.795/- per annum. Therefore, as against the view revenue loss of Rs.4.13 lakhs per annum, because of the submersion, the additional benefit from irrigation will be Rs.795 x 8550 acres = Rs.68 lakhs per annum. The Government therefore direct that an extent of 131.56 acres of forest land be placed at the disposal of Public Works Department the implementation of the Aniar Reservoir Scheme in the Shevaroy North Range of Salem Division.

4. As these are sandalwood tress in this area, the Chief Conservator of Forests is directed to ensure that no attempt to illicitly cut those trees is made. A total census of the sandalwood trees in the acres should first be taken by the Forest Department and action

taken to cut these sandalwood trees. Only after cutting the sandalwood trees, the other trees in the area should be cut and removed.

5. The Chief Conservator of Forests (General) is also directed to take up aforestation work immediately on an equal acreage of land now transferred to the Vaniar Reservoir Project.

(By Order of the Governor)

G. Thirumal,
Commissioner & Secretary to Government

To

The Chief Conservator of Forests (General), Madras-6.
The Conservator of Forests (Irrigation), Madras-5.
The Conservator of Forests, Salem Circle, Salem.
The District Forest Officer, Salem Circle, Salem.
Copy to Public Works Department, Madras-9.

/True Copy /

Sd/-
Section Officer

ANNEXURE

Thiru R. Ganesan, B.E. (Hons) MIE
Superintending Engineer, PWD

Spl.Projects Circle
Krishnagiri.

D.O.Lr.No.534/82/F62-A/D4

Dated: .10.82

Dear Sir,

Sub: Irrigation - Dharmapuri District - Vaniar Reservoir Project - Taking overof Forest lands in Water spread area - delay in handing over the Forest lands by the Forest Departments - reg.

Ref: G.O.Ms.No. 994, Forest & Fisheries Department, dt.14.09.79.

The Govt. in G.O.Ms.No. cited has accorded approval for placing an extent of 131.56 acres of Forest lands coming under water spread area of Vaniar Dam at the disposal of Public Works Department for the implementation of the Vaniar Reservoir Project Scheme in Shervaroys North Range of Salem Division.

Though more than three years have elapsed since the date of the Govt. orders, the Forest Department has not handed over this extent of PWD inspite of innumerable correspondences, personal contacts, and discussions. A note on the same is submitted herewith which will reveal the efforts taken by this department to the maximum extent.

In this connection I am to add that the earth required for the formation of dam so far have been taken from the Patta lands and the same is almost exhausted. Unless the Forest lands as ordered in the G.O. cited is handed over atleast before December'82 the work will come to a grinding halt.

I therefore request that the matter may please be takenup with the Chief Conservator of Forests (General) and to PWD for expediting matters.

With kind regards,

Yours sincerely,

sd/-

(R. Ganesan)

Encl: One Note

To

Thiru A.Mohanakrishnan, B.E.(Hons) Msc. MIE
Chief Engineer (I) PWD
Chepauk, Madras - 5.

NOTES ON THE FOREST LAND TO BE HANDED OVER TO PUBLIC WORKS DEPARTMENT FOR THE CONSTRUCTION OF

VANIAR RESERVOIR PROJECT

The Government in G.O.Ms.NO.994 Forests & Fisheries Department dated 14.09.1979, has accorded approval for placing the Forest pLand coming under water spread area of Vaniar Dam at the disposal of Public Works Department for the implementation of the Vaniar Reservoir Project Schemes in Shervarays North range of Salem Division.

As per para 2 of the G.O. cited the original proposal sent by the Chief Engineer (Investigation), the extent of Forest land liable for submersion was given as 234.10 acres and in the final proposal the extent was stated as 131.36 acres coming under water spread area and based on which the Government has accorded approval for placing an extent of 131.56 acres of Forest Land under submerssion at the disposal of Public Works Department.

The Chief Conservator of Forests (General) vide his Lr.No.G3/113313/77-9 dated 14.12.79 addressed to the Conservator of Forests, Salem Circle with copies to Dist. Forest Officer, Salem and to the Superintending Engineers, Spl. Projects Circle has instructed to give effect to the G.O. Accordingly the Conservator of Forests and Dist. Forest Officer Salem were addressed to hand over the Forest Lands. The Chief Engineer (I) vide Chief Engineer's lr.No.P4/15737/79-14, dt.28.02.80. has also addressed the Chief Conservator of Forests to arrange to hand over the required lands to the Executive Engineer, Vaniar Reservoir Project Division, Harur at the earliest.

The Chief Conservator of Forest Madras was also addressed by the Superintending Engineer vide Lr.No.104M/80/F62A. dt.13.03.80. inviting the Chief Conservator of Forests Lr.No.G3/113313/77-9 dt.14.12.79 to permit the Public Works Department to enter upon the land and also to give suitable instructions to local officers accordingly.

The Chief Conservator of Forests vide his Lr.No.G3/113313/77-18 dt.22.07.80. has addressed the Chief Engineer to inform whether the extent of 131.56 acres of Forest lands have been demarcated and shown to District Forest Officer Salem by the Local Officials for taking further action by their department. The sketch of the 131.56 acres of lands was also requested.

The Executive Engineer, Vaniar Reservoir Project Division-I Harur vide his Lr.No.38M/F28/D2, dt.30.12.80. has furnished the sketch to the Chief Conservator of Forests Madras clearly the showing the extent of 131.56 acres and informed that the extent also damarcated on ground.

The Executive Engineer vide his Lr.No.38M/F28/D2, dt.30.12.80. has addressed the Chief Conservator of Forest to obtain the orders of the Government to place a total extent of 234.10 acres at the disposal of Public Works Department as on further examination it was found that the extent of 131.36 acres ordered in G.O. will not be sufficient for the project work thus seeking for additional extent of 102.74 acres totalling 234.10 acres. The Chief Engineer (I) was also addressed in this regard in my Lr.No.323CE/F62A dt.15.06.81.

Leaving the above additional extent of 102.74 acres, the Forest Department officials were being addressed on various occasions to hand over the forest lands ordered in the G.O. cited in order to push thro' the work with specific mention that the Heavy Machinery Units for formation of Earthdam have already arrived at site and the work is held up for want of borrow area to remove earth.

The subject was also discussed by the Chief Engineer (I) on 02.07.81. with the Chief Conservator of Forests and the Chief Conservator of Forest has also agreed that the Forest lands already ordered to be handed over to Public Works Department in the Govt. order do not come under the preview of the ordinance issued by the Govt. of India, as stated by the local officials of the Forest Department and stated that there is no difficulty in handing over the lands to Public Works Department vide Chief Engineer's Lr.No.P4/48756/81-1, dt.03.07.81.

The Chief Conservator of Forests vide his Lr.No.G3/113313/77-2, dt.04.06.81. addressed to the District Forest Officer, Salem Division, Salem has persumed that the Dist. Forest Officer would have handed over the charge of the area to Public Works Department under a proper TCR. The Conservator of Forests has also instructed the Dist. Forest Officer to do so at once if not already done, with instructions to take separate action for the additional extent of land required for getting the approval of the Govt.

The Chief Conservator of Forests during the inspection of water spread area of Vaniar Dam site on 15.07.81. has orally informed the Executive Engineer, Vaniar Reservoir Project permitting the Public Works Department officials to clear the bushes and wild growths so as to remove the earth for the formation of the earthdam. The Executive Engineer has also addressed the Chief Conservator of Forests for confirming the oral instructions and also to issue suitable instructions to the Dist. Forest Officer for removing the trees at an early date and to hand over the lands to Public Works Department for taking up the works in full swing. The Dist. Forest Officer was also addressed by me with a copy to the Chief Conservator of Forests for urgent action in this regard vide this office Lr.No.360m/81/D$/F62A dt.29.7.81. submitting a copy to Chief Engineer (I). The above was also informed in my letter No.410 CE/81/F62A/11.08.81. to the Chief Engineer (I)

The Chief Conservator of Forests, Dist. Forest Officer and Conservator of Forests were being reminded in this regard. The Chief Conservator of Forests vide his Lr.No.G3/11313/77-24 dt.12.08.81. has addressed the Dist. Forest Officer to report the action taken in the matter of handing over the lands to Public Works Department.

The Conservator of Forests Salem vide his Lr.No.C.No.D1/30501/79, dt.29.08.81. has informed me that necessary instructions were already issued to the Dist. Forest Officer, Salem in this regard. The Chief Conservator of Forest vide his Lr.No.G3/113313/77-25 dt.12.10.81. has instructed the Dist. Forest Officer to hand over the lands to Public Works Department.

The Chief Conservator of Forests vide this Office Lr.No.546M/81/F62A/D4, dt.16.10.81. was addressed to instruct the Dist. Forest Officer to hand over the lands to Public Works Department and also to allow for removing the earth as the local forest officials refused the Public Works Department to remove earth stating that they have not received any written orders to do so.

The Chief Engineer (I) vide Lr.No.P4/48756/81-4 dt.06.11.81. has addressed that Chief Conservator of Forests to this effect.

The Dist. Forest Officer vide his Lr.No.C.No.14804/79/D2, dt.09.12.81. has reported to the Executive Engineer that the area in question has been surveyed and computed as 135.67 acres and requested to inform whether the PWD requires 135.67 acres or 131.56 acres.

The Chief Conservator of Forests vide his Lr.No.G3/113313/77-28, dt.08.12.81. has requested the Dist. Forest Officer to hand over 131.56 acres as ordered in the G.O. and report the fact with a copy of T.C.R. atonce.

The Chief Conservator of Forest vide his Lr.No.G3/113313/77-27 dt.28.12.81. has instructed the Dist. Forest Officer to exclude the excess area of 4.11 acres thereby limiting the area to 131.56 acres as ordered by the Govt. inconsultation with the Public Works Department to locate the exclusion of the excess area and to modify the demarcation on the ground & sketch of the area accordingly.

The Executive Engineer, Vaniar Reservoir Project Division-I, Harur vide his Lr.No.573M/F28 dt.03.03.82. addressed to Dist. Forest Officer, Salem Division, Salem has enclosed the sketch showing the extent of 131.56 acres deleting 4.11 acres of lying within the water spread area informed that this extent is beg marked on the ground. The Dist. Forest Officer was also informed that separate proposal will be sent requesting the transfer of 4.11 acres. The urgency of handing over the forest land as ordered by the Govt. was once again stressed.

This matter was discussed with the Chief Engineer (I) on 06.04.82. the Chief Engineer has instructed that we can restrict the area to be taken over from the Forest Department to 131.56 acres by marking a parallel line from the F.R.L. line to the level required to get this area.

In this connection I had discussion with the Conservator of Forests, Salem, Dist. Forest Officer along with the Executive Engineer, Vaniar Reservoir Project Division - I, Harur at Salem on 11.05.82. The minutes of the discussions is enclosed. The following were decided there.

1. To place 131.56 acres of land as ordered in the G.O. at the disposal of PWD for the implementation of Vaniar Reservoir Scheme in the Sevaroys North range of Salem division and to get the order of the Central Govt. for the transfer of the difference in extent viz. 4.11 acres to PWD.

2. To take action to clear of all the tree growths in the said 131.56 acres of Forest land as early as possible and to arrange to hand over to PWD very early.

3. Pending clearance of the tree growth such of vacant lands to the tune of 50 acres where there is no growth and which is demarcated after joint inspection by the Dist. Forest Officer and Exe. Engineer to be handed over immediately to PWD for removal of stones and earth for the formation of the Reservoir and to keep the works going which may otherwise have to be stopped for want of borrow area and quarry.

The minutes of the discussion was communicated to the Conservator of Forests and Dist. Forest Officer vide to this office Lr.No.341M/82/F62-A/D4 dt.12.05.82.

The Conservoir of Forests based on the discussions held has instructed the Dist. Forest Officer vide his Lr.No.30501/79-1/D3 dt.12.05.82. has instructed to take action accordingly.

After the joint inspection by the Exe.Engineer and Dist. Forest Officer it was agreed to permit the removal of earth and rough stone in the coup No.I measuring 65.25 acres. Accordingly the Conservator of Forests, Salem was addressed in this Office Lr.No.528M/82/F62A/D4. dt.17.07.82. addressed to the Conservator of Forests, Salem has reported that necessary permission will be accorded to PWD after getting the sketch of the area from the Ranger where the PWD want to collect the earth, and stated that there are two nos. of Thanakku trees and these trees can be removed when the Southern Match Industries come forward for extracting these two soft wood trees.

The Dist. Forest Officer & the Conservator of Forests Salem were addressed by me and the Exe.Engineer on 22.05.81, 16.07.82, 27.07.82, 31.07.82, 05.08.82, 18.08.82, 30.08.82, 07.09.82 and 25.09.82 for expediting matters and to hand over the Coup.No.I with an extent of 65.25 acres first in order to proceed with the work without interruption and to hand over the remaining extent of 66.31 acres at an early date after the felling of the trees stressing the urgency of the work being a time bound project.

The Collector of Dharmapuri has also addressed the District Forest Oficer vide his Lr.No.66521/82-88, dt.28.05.82 and even No. dt.10.07.82, 11.08.82, 30.08.82 and 17.09.82 to give immediate effect to the G.O. and to hand over the lands urgently.

Sd/-
Superintending Engineer, PWD
Spl. Projects Circle, Krishnagiri.

Encl.: Minutes of the discussion with the
Conservator of Forests.

Copy of Lr.No.341M/82/F.62A/D4/dated 02.05.82 of the Superintending Engineer, PWD., Special Projects Circle, Krishnagiri-635 001 addressed to this Conservator of Forest, Salem Circle, Salem.

sub: Forests - Dharmapuri District - Vaniar Reservoir Scheme near Mullikadu village in Harur Taluk. Forest areas involved - Concurrence of Forest Department - Handing over of the lands - Minutes of discussion - regarding.

Ref: Arising

Further to our discussions held on 11.05.82 at 11.00 am in your Chambers regarding handing over of Forest lands to Public Works Department for the formation of Vaniar Reservoir near Mullikadu Village of Harur Taluk, Dharmpauri District, I enclose minutes of Discussion for information and concurrence.

I request the forest lands may be arranged to be handed over to Public Works Department very early for removal of earth and stones and use them in the formation of earthern bund and revetment.

Thanking you,

Sd/-
R.Ganesan, 11.05.82.
Superintending Engineer, PWD
Special Projects Circle, Krishnagiri

Encl.: Minutes of Discussion - 1No.

Copy with copy of minutes of discussion to the District Forest Officer, Salem for information and further action. It is requested that the lands may be arranged to be handed over early.

Copy with copy of minutes of discussion to the Exe.Engineer,PWD. Vaniar Reservoir Project Division No.I, Harur. Proposals for transfer of difference in extent of the area (I.E.) 4.11 acres may be sent early. Pending handing over of the full extent vacant lands where there is no growth of trees may be identified, got demarcated after joint inspection with District Forest Officers, Salem and arranged to be taken over, and start removing of earth and stones for use in the formation of bund and building revetment.

/ True copy /

Sd/-
Superintending Engineer, PWD
Special Project Circle, Krishnagiri

COPY OF

Minutes of discussion held on 11.05.82 at 11.00 a.m. at the Chambers of Conservator of Forest Salem regarding handing over the Reservoir Forest Lands to Public Works Department for the formation of Vaniar Reservoir Project near Mullikadu Village, Harur Taluk, Dharmapuri District.

OFFICERS PRESENT

1.	Thiru.Wilson, IFS	:	Conservator of Forest, Salem
2.	Thiru.R.Ganesan, B.E., M.I.E.	:	Superintending Engineer, PWD. Special Projects Circle, Krishnagiri.
3.	Thiru.Arul Prakasam, IFS	:	District Forest Officer, Salem
4.	Thiru.M.K.Natarajan, B.E.,M.I.E.	:	Executive Engineer, PWD., Vaniar Reservoir Project Division No.I, Harur.

The following were decided after discussions

1. As per G.O. Ms.No.994 of Forests and Fisheries Department dated 14.09.79 an extent of 131.56 acres of Forest land which goes under submersion is to be placed at the disposal of Public Works Department for the implementation of the Vaniar Reservoir Schemes in the Shevaroys North range of Salem Division. However after actual full Reservoir level survey the area has now been computed by the Forest Department as 135.67 acres. The difference is due to short assessment earlier which was based on rough survey done originally during investigation of the scheme. As the scope of the scheme has not been changed, as the full reservoir level remains to be the same, and as the scheme has been sanctioned by State Government as early as 2/1979 and is halfway through and also approved and cleared by the central water commission New Delhi, the total extent of lands that goes under submersion is to be handed over to Public Works Department. Action is to be taken to get the orders of the Central Government for the transfer of the difference in extent (.e.) 4.11 acres also to Public Works Department.

(Action Forest Department and Public Works Department)

2. Action is to be taken to clear of all the tree growth in the said 131.56 acres of forest land as early as possible and arrange to hand over to Public Works Department very early.

(Action Forest Department)

3. Pending clearance of the tree growth such of vacant lands to the tune of 50 acres where there is no growth and which is to be demarcated after joint inspection by District Forest Officer and Executive Engineer, may be handed over immediately to Public Works Department for removal of stones and earth for the formation of the reservoir and to keep the works going which may otherwise have to be stopped for want of borrow area and quarry.

(Action Public Works Department and Forest Department)

ANNEXURE

GOVERNMENT OF TAMILNADU
PUBLIC WORKS DEPARTMENT

INSTITUTE OF HYDRAULICS AND HYDROLOGY,
POONDI

VANIAR RESERVOIR PROJECT

Further Studies made to finalise the Surplus Course, Drops and Trough Aqueduct

1. H.H. Report No.1/82

VANIAR RESERVOIR PROJECT

INTERIM REPORT NO.1

I.H.H. Report No.: 21/81

I. INTRODUCTIONS:

Superintending Engineer (Designs) in his letter No.AEE IV/7009/77 dated 05.02.1981 furnished designs drawings for the Vaniar Reservoir Project surplus arrangements consisting of a flank regulator, a surplus course with a series of deeps joining the river downstream. Studies were taken up to check up the energy dissipation downstream of the regulator, flow conditions at the drops sites and any erosion or other deleterious effects at the point where the surplus course joins the main river.

2. DATA:

The hydraulic particulars pertinent to the problem are furnished below:

Max flood discharge	:	654.9 cumecs (23,128 cusecs)
Discharging Capacity of the surplus regulator	:	669.22 comecs (23,650 cusecs)
Discharge capacity of the surplus course	:	676.54 cumecs (23,888 cosecs)
Bed width of the surplus course	:	53.0M
Bed fell	:	1 in 2,968
Length of surplus course	:	1220 M.

3. MODEL:

A comprehensive model depicting the regulator surplus course and the main river Vaniar downstream was constructed to a scale of 1 in 50. The surplus course was cut in length to suit the area available maintaining the relatives alignment at the point of confluence.

4. EXPERIMENTS:

I. Experiments were done initially to finalise the energy dissipation arrangements in the rear of the regulator. Basins of length 12,5,15,17.5 and 25M length and 1.4M depth were tested. Tail water depth of 5 M over the apron elevation was maintained. The water surface profiles are shown in fig.1 and the velocity distribution in the tail channel is indicated in the Statement No.1. it is seen that a 12.5 m basin is suitable.

II. The flow condition in the surplus course with 2m drops at different locations as proposed by the S.E. (Designs) was observed. It was seen that high velocity of flow of the order of 21 ft/sec. was persisting throughout the length of surplus course and the depth was also 1.75 M. as against 5 M. The design was reviewed. It was seen that the drops induced a draw-down effect which had not been countered effectively as it is nor-

mally done by providing netches in the case of similar drops in channels. As this was a flood way it was felt that notches may form obstructions for floating logs and therefore some other remedial measure had to be thought off. An obvious choice was raising the crest of the body wall in lieu of notches. Experiments were done with the body wall raised pby a crest of heights 1M, 1.5M and 2M Depths upstream of the drops were measured and it was found that only with a raised crest of 2M of the designed depth of flow could be maintained in the channel. The flow profile along the surplus course with a great of body wall raised by 2 M is given in fig.2. The velocities were observed to be of the order of 15'/sec. When 5M baffles at 11 M from toe of drops were provided velocities were observed to be well with in the limits being less then 10 ft/sec.

As an alternative surplus channel between drops was formed with reverse slope from the tea of a drop to the crest of next drop. It was observed that this arrangements gave rise to smooth flow performance but the velocities at different points were of the order of 15 to 18'/sec. Therefore it is not considered suitable.

5. CONCLUSION:

5.1. The design of the regulator and the surplus course with drops was tested in a comprehensive model to a scale of 1 in 50. It is recommended that a sunk type stilling basin 1.4m deep and 12.5 m long may be formed below the regulator for energy dissipation.

5.2 In the case of drops it is recommended that the crest of the body wall should be 2M above the bed level of the surplus course for maintaining the design depth of 5M in the surplus course.

5.3 As the drops are in a series and a design depth of 5M is maintained no water cushion is seen to be necessary for dissipating the energy of fall at the drops. Except that a 0.5M baffles is found necessary to intercept the high velocity bedevilment. A simple concrete floor at the bed level of the surplus course to a length of 15 M will be all that is required for protection.

5.4 There are no specific remarks to be given on the proposals for bed pitching and revetment as the design depth of flow can be maintained and they can be decided to suit the field conditions.

6. FURTHER STUDIES:

The cross sections of the main river Vaniar on either side of the confluence have now been received. A mobile bed river model will be formed and any problem at the point of confluence will be studied in detail.

Sd/- Chief Engineer, PWD
Inter State Water and Director
Institute of Hydraulics and Hydralogy
Chennai - 600 005.

B - Bottom
T - Top

STATEMENT-I VELOCITIES IN FT/SEC.

Basin Length	Distance from the Rear of the Dam 50M	60M	70M	80M	90M
12.5M 7.26		B 5.63	5.63	5.63	5.63
	T 8.60	6.50	5.63	5.63	6.50
15M	B 6.50	5.63	5.63	5.63	5.63
	T 8.50	7.26	7.96	5.63	8.50
17.5M	B 8.60	5.63	5.63	5.63	5.63
	T 9.19	8.60	8.60	6.50	6.53
25M	B 7.96	18.27	8.68	6.50	-
	T 10.78	9.75	8.60	8.60	-

VANIAR RESERVOIR PROJECT

INTERIM REPORT II

1. INTRODUCTION:

The Chief Engineer (Irrigation) PWD in his letter No.P4/15737/79-102, dated 26.08.81. furnished designs drawings for the Vaniar Reservoir Project surplus arrangements consisting of a flank regulator, a surplus course with a series of drops joining the river downstream. Studies were taken up to finalise the energy dissipation arrangements below the spillway, flow condition at the drop sites and any erosion or other deleterious effects at the point where the surplus course join the main river.

2. Data:-

The hydraulic particulars pertinant to the problem are furnished below:-

Max. flood discharge	:	654.9 cumecs (23,128 cusecs)
Discharging capacity of the surplus regulator	:	669.22 cumecs (23,650 cusecs)
Discharging capacity of the surplus course.	:	676.54 cumecs (23,858 cusecs)
Bed width of the surplus course	:	53,00 M
Bed fall	:	1 in 2960
Length of surplus course	:	1220 M

3. MODEL:-

A comprehensive model depicting the regulator, surplus course and the main river Vaniar downstream was constructed to a scale of 1 in 50.

4. EXPERIMENT SET UP:

In the interim report No.1 experiment for arriving at the energy dissipating arrangements as well as for finalising the design of the surplus course have been detailed.

i. Proposed through aquduct at L.S. 710 M of surplus course

Subsequently the Executive Engineer Division II Vaniar Reservoir Project has requested this Institute to conduct model study for the proposed through aquduct at L.S. 710 M of surplus course. Based on the plans and drawings furnished by the Executive Engineer, Division II of Vaniar Reservoir Project, Model studies have been conducted.

The hydraulic particulars at the canal crossing Canal

1.	Bed width of canal	1.80 M
2.	Full supply depth	0.70 M
3.	Side slope	1:1
4.	Bed slope	1 in 2500
5.	Velocity	0.748M/sec
6.	Discharge Designed	1.309 cumec
7.	Discharge required	1.279 cumec
8.	Bed level at Entry (125M)	450.840 M
9.	Bed level at Exit (175M)	450.820 M

AQUDUCT

1.	Equivalent section (for no head loss)	2.50M x 1.00M
2.	Full supply depth	0.70m
3.	Bed level surplus course at the crossing point	445.785M

During model studies it was observed that the proposed aquduct can be placed such that the central line of the aquduct may be at a distance of 6.5 m from the drop at LS 685 M with any change in the surplus course or drop. The only suggestion made here is that the aquduct must be constructed parallel to the body wall of drop and normal to the flow in the surplus course. For that necessary arrangements can be made at the entrance as well as the exit of the canal alignment be have easy flow in the aquduct. In fig.No.1 the Hydraulic performance are furnished. It may be seen that the location of the aquduct has been so fixed as to clear the nappe of the dropping flow for the maximum flood discharge. In order to understand the behaviour of the nappe for lower dischrges. The hydraulic performance was observed for the lower flow in the surplus course such as 1/4.1/2 and 3/4 of maximum discharge. The water surface profile observed and velocity distributions are furnished.

ii. Study with reduced sections at the drops.

A suggestion was made whether heading up of flow could be obtained by reducing the drop width suitably. Studies have been made at the surplus course for the various reduced widths at the drops site (that is) to have a single notch type of 35M width with 0.5M crest at the drop section. It is observed that the flow performance is not good. There on baffls walls of various heights of 0.5M, 1.0M, 1.5M and 2.0M at a distance of 12.5M from the drop section were also tried. 5 M depth or flow in the surplus course has been obtained only with 2.0M baffie wall but the performance of the hydraulic jump is

not good. It is observed that there is high velocity which required additional arrangements for the energy dissipation.

On the same lines, the performance with 40m width of drop with 1.0M crest has been studied. The hydraulic jump performance seems to be tolerable with 2M baffle wall at 12.5M distance. In this case also it is observed that there is 5M depth of flow in the surplus course and the velocities are slightly high (i.e) about 10.0'/sec.

It is seen that even with 2.0M baffle wall and with 1.0M crest for the reduced section of 40M the flow performance is not as good as providing 2.0M hight 2.5M width body wall for the entire width of 53M.

5.0 CONCLUSION

i. Proposed through aquduct at LS 710 M of surplus course

An aquduct of size 2.5M x 1.0M can be constructed such that the central line of the proposed aquduct is at a distance of 6.5M from the drop at LS 685 M. The proposed aquduct must be parallel to the drop section and normal to the surplus course. Necessary arrangements are to be made at the entrance and exist of the aquduct to have smooth flow in the aquduct.

It is suggested that the body wall to a width of 53M at each drops section may be adopted with a 2.5 M broad crested with crest level 2M above upstream bed level as already suggested in the interim report I (communicated in L.O. letter No.TA/STO/R-05416-1/81, dated 13.11.81.). The other trials made as above described do not give satisfactory results.

Sd/-
For Chief Engineer, PWD
Inter State Waters and Director
Institute of Hydraulics and Hydrology
Poondi-602 023.

CHAPTER 11
PRELIMINARIES SITE CLEARANCE WORKS

11.1 CLEARANCE IN VARIOUS STAGES

11.1 In Vaniar Project the site clearance works were carried out in stages almost simultaneously with the construction of its various components. There was no necessity nor it was found feasible to do them in one go; the reason was that the campus buildings and roads were spread over various fields which were both Patta and Revenue Poromboke lands. Entries into these sites were not possible in one and the same time. The alignment of the dam and surplus course passed through several private agricultural lands which could be taken possession of in different periods of time only. The hurdles was only the hillock portion in the dam alignment between L.S. 640m and the steep hill slope at the right flank end. These were tackled separately, otherwise, the site clearance works in this project presented no problem. They were got done according to standard specifications under the various contracts and agreements for buildings, roads and earth works in the dam site campus etc. and their costs were either included in the respective lumpsum contracts or paid for as separate items as the case may be.

11.2 Removal of bushes and debris, dressing down mounds and minor rocky out crops and levelling ground in a limited scale were first taken up in August-September, 1979 to prepare detailed site survey maps with levels for finalising the designs and drawings for the dam components and campus buildings. To start with, these activities were confined to the Government Poromboke lands in the dam site where store sheds and camp offices were to come up; still the Patta lands could not be eliminated completely. Around the same time, the margins of the first access route - the cart track - to dam site from Venkatasamudram Village - were cleared off all obstruction and made jeepable.

11.3 CEREMONIOUS START OF THE WORKS

It was programmed to take out the first sod of earth to herald the commencement of the project works on 19.09.79 after a simple ceremony. The then Commissioner Secretary to the Government, PWD, Thiru B Vijayaraghavan, IAS was to take part in the function as the Chief Guest who was to take the spade bring out the first clod of earth followed by then Chief Engineer, PWD, Irrigation, Thiru.S.Manavalan. Planting of sapling that day by these dignitaries was included in the agenda. The simple ceremony, in which all the villagers took part enthusiastically, was conducted very well on 19.09.79.

11.4 STAGES OF PROGRESS

The site clearance works in the various spots were mostly completed by June, 1982. However, these works along the shifted alignments of the forest road above the full reservoir level contour and in certain branches of left and right main canals had to be taken up after 1983 for unavoidable reasons. The lands in these locations were placed at the disposal of PWD in stages till the end of the year 1984.

11.5 In the private agricultural lands at the out-skirts of Pappireddipatti and in the poromboke lands in Harur town, the site clearance was taken up after the tenders for staff quarters and office buildings to be built in these small towns were received on 19.12.79. Several agencies were involved in these tasks as each building or a block constituted one tender. A number of small and marginal local contractors were encouraged to complete in order speed up the progress.

11.6 The large scale operations under this head - viz., site clearance and earth works - had to be done along the alignments of the dam proper and the surplus course. In the case of the former, the stretch to be tackled was over 1,300 meters and for the later it was nearly 1 (one) kilometre. In order to speed up the progress and to encourage small contractors, the works were split up and proposed to be entrusted to several bidders in anticipation of approval of special powers by the Government. The buildings are programmed to be completed in two stages - the first stage upto basement and the second above it. The dam and surplus course were divided into several sections (reaches) and separate working estimates got prepared for each portion and competitive offers were invited. While such divisions and distributions among many contributed to the early completion of the works, this proposal also came in handy for providing the displaced persons with works and remuneration to rely upon till their permanent settlement elsewhere were finally thought off.

11.7 HIGH BIDS AND LACK OF RESPONSE

There were no offers for some of the buildings in Harur town and Pappireddipatti. In the case of dam site works too, around this time, this lack of response was felt. The road formation works also were affected by this trend. In respect of excavation works for the surplus course, out of 6 (six) reaches put to tender, there were valid offers only for 3 (three). Two bids were in excess of estimate rates by as much as 70 percent. In the case of buildings, the wood works and joinery items were quoted high. The highly priced tenders were rejected and action taken to entrust some of the works atleast on nomination basis to eligible contractors at rates not exceeding the estimate rates. The unit rates for earth work items were so unworkable that only a few piece work contractors came forward to execute the work at or below estimate rates. In fact the Executive Engineer, Head Works Division, V.R.P. had remarked in the B Form progress report for January, 1980, that unless realistic rates for earth works were not fixed, progress of works will be greatly affected.

11.8 SCHEDULE OF RATES (1980-81) INCREASE ATTEMPTED

In the meantime actions were taken to revise upwards the rates for earth work and site clearance and wood work items in the schedule of rates applicable for Salem-Dharmapuri circle. The contractors wisely preferred to wait till the hike came into effect after 1.4.1980. The Executive Engineers of the project divisions who attended the schedule of rates conference conducted in February, 1980 by Superintending Engineer, PWD, Salem-Dharmapuri circle pleaded effectively for raising the unit rates for earth works under various classifications of soils for embankment formation and canal excavations. Appreciable increase could not however, be obtained for these items. The reasons are

analysed in the following paragraphs.

Double the rates as for open excavation are allowed for foundation excavations in buildings contracts. But this is not the case in respect of large open excavations in projects and irrigation works. Further, the cost of earth works forms a small percentage of the total agreement sum for a building work. Therefore, the rates quoted for earth works in tenders for buildings would not be much different from a departmental rates for these items. For the district as a whole, the number of tenders for building works and repair works in a year is normally much higher than the tenders dealt with by a project division where earth work constituted a major portion. If a statistical average is struck for the quoted rates of earth works in all the tenders received for one year in question, the figure would not be much higher than the existing schedule of rates. In this context the arguments for hike in the unit rates for earth works by the Project Engineers becomes unconvincing.

11.10 Another aspect which is usually lost sight of or perhaps not given due consideration is the output variation for works over the years by same set of workers. The present day labourers engaged in earth work excavation in different kinds of soils are not as strong physically and not as much disciplined mentally as their fore runners a few decades ago. The quantum of work done by the mazdoor now is less than what it was before. The daily wage of a mazdoor is stepped up every year in tune with the general inflation index and the work item rate is accordingly refixed assuming no variation (i.e. reduction) in the output per worker. When payments are claimed and disbursed on the basis of number of days worked - as is usually the case on the nominal muster roll (NMR) basis, departmentally - the distortion in the unit rate fixed in the annual schedule of rates conference for the item of work for which these labourers are engaged becomes apparent; because the quantity of work turned out by the labourers is not as much as it should have been, had the workers exhibited the same effectiveness and competence as their counterparts in the earlier years.

11.11 CEILING RATES - BASIS AND PROCEDURES

These intrinsic issues get resolved to a great extent in the recommendations of ceiling rates for certain items of works in the project sites. The conditions under which works are carried out in project areas usually situated in remote interior places bordering hills and reserved forests are different compared to those in plains elsewhere. Transit times from the place of residence to work spots and expenses for the to and fro journeys are more in the case of the former. Demands for higher wages arise from these factors. The urgency shown by the scheme officials in finishing the critical items of works before the onset of monsoon and their commitment to keep to the scheduled programmes for making way for the machinery etc. to start functioning have their own influence in pushing up the prices. These trends were apparent in the case of Vaniar Project too.

11.12 The basis for the ceiling rate is that they should be workable and should result in affording reasonable profit to the piece workers. This was achieved by arranging execution of works departmentally in the first instance and watching the job our turns. Records of observed rates of this nature were maintained and produced during the inspections of higher authorities and copies sent for exami-

nation in circle office along with the recommendations for fixing ceiling rates. The percentages of excess quoted for tenders floated around the same time for works of similar nature also provided an idea for arriving at the reasonableness of the ceiling rates. The ceiling rates are approved by the Superintending Engineer, Projects Circle when the difference between the ceiling rates and the corresponding schedule of rates is not much, otherwise the matter is referred to the Chief Engineer for concurrence.

11.13 SITE CLEARANCE WORKS IN VANIAR SITE - SPECIFICATIONS ADOPTED

All perishable materials were stripped out and the ground surfaces everywhere were kept cleared off brush wood, prickly pear and light jungle vegetation. The roots were grubbed out and the stumps pulled out. There were only a few trees in the dam site which were auctioned off after issue of short tender notices. The highest bidders were allowed minimum time to cut and remove the trees which were previously inspected by the Executive Engineer and approved for removal. The bidders were specifically instructed to clear the sites as above: Except where specifically stated, all the products of site clearance became the property of the Government. They were suitably disposed off. In Vaniar Dam site, the materials so obtained we not of much consequence, nor of high value. The site was largely barren with small and medium tree growths here and there. The procedures for auctioning and collection of bid amounts before removal of the trees etc. were formally observed. The villagers and workmen took away the brush wood, roots, etc. got them dried and used them as fire wood for cooking purposes.

Stripping top soil, removal of vegetation and levelling ground were done during the month of February, 1980 at the sites chosen to put up quarters for technicians and drivers in the campus area of the Head Works. These works had to be urgently completed as without quarters the heavy machinery crew would not start the work and the division had to meet the idling charges equipment unnecessarily. During April, 1980, the site clearance works were taken up in two sections of the earth dam, L.S. 300 m to 600 m and from L.S. 1,100 M to 1.210 M and also in some reaches of the 1200 M long surplus course.

During the same time, the clearing works in the hillock situated between 640 M and 730M of the earth dam alignment were also attended to. This was a difficult job as number of boulders were to be blasted and removed. About 350 laborers were engaged in this task.

11.14 The earth dam reach between L.S. 750 M and 1040 M could be tackled only during the months of September, October, 1980 after compensations for standing crops were paid and tenders for cut-off trenches in these reaches were settled. The clearance works on this portion were accordingly taken up later. The surplus regulator and the two tower head sluices for the left and right main canals were located in the portions between L.S. 230 M to 290 M, 730 M to 750 M and 1,300 M to 1,320 M respectively. Site clearance works in these reaches were included in the contracts for these major components and were done when constructions in these sites were taken up.

11.15 CONSTRAINTS FACED BY THE DIVISION

As it is common for an organisation starting from a scratch, the head works division too, faced difficulties during its earlier stages. Private buildings which could cater to all the needs of an Executive Engineer's office were rare to find in a small town like Harur. The same situation was existing at Pappireddipatti also where three sub-divisional offices had to be located. The officers had to be put up with the inconvenience of functioning from rented houses lacking in many facilities till own buildings for accommodating the division and the sub-division offices were completed in March-April, 1980. For securing the telephone facility for the Executive Engineer's office, they had to wait for another two years. Limited items of furniture brought from the old closed divisions in Thanjavur District, were only made available for the use of the office staff.

11.16 The full time Executive Engineer joined on 26.07.79, about one and a half months after the formation of the division. During this interval, the Executive Engineer of the Salem Division who had a vast jurisdiction himself was holding additional charge of the Vaniar Head works Division. Two Assistant Executive Engineers and 13 (thirteen) Assistant/Junior Engineers out of the sanctioned strength of 4 (four) and 17 (seventeen) of these cadres respectively had reported for duty two to three months later by July-August 1979. The appointment orders to clerical personnel were not issued till October 7, 1979. The Administrative staff took longer time to function from their respective seats. The Divisional accountant joined duty as late as March, 1980. Some vacancies in the typists and clerical cadres lasted till 3/1982. Financial sanctions and issue of letters of credit to enable the Executive Engineer and the Assistant Executive Engineers to issue claques and draw money from the State Bank of India were held up till October, 1979. Essential expenditure had to be incurred through the accounts of Salem Division.

11.17 An old van and a very old jeep only were in use in the Division during the early months. Another set in an equally run down condition were transferred to this Division's control a few months later (in 12/1979). The Engineers had to manage with these old vehicles which broke down often. All major facilities for repairing them properly were not available in Harur town. Hence the vehicles had to be taken to Salem town and brought back after getting them back to running condition. Some of the repairs had got to be attended to in Salem till the small auto workshop in Dam site became fully operational. All the sub-divisional officers were not provided with vehicles till as late as 5/1982. The absence of jeeps in good order affected the mobility of the inspecting officers to a certain extent. The field staff faced and overcame these difficulties and showed satisfactory progress in the usually irksome preliminary stages.

CHAPTER 12
PROTECTION WORKS - RIVER DIVERSION, COFFER DAMS, ETC.

12.1 PLANNING THE DIVERSION

12.1.1 GENERAL

Coffer dams are temporary structures that form an enclosure in the river course to enable excavation and construction of dam components under dry conditions, the seepage being removed by dewatering pumps. The coffer dams can be of masonry, or earth or even of timber depending upon the nature of the river bed and frequency of floods. Generally the scheme of water diversion should be such as to deal with minor floods leaving the major ones to overtop the coffer dam and flood the work area. For building dams across deep gorgeous, a tunnel is formed through which the river flows are kept diverted until the completion of the dam structure and afterwards the tunnel is closed (plugged). In other cases, the river discharges are guided and based over different portions (usually 3 (three) of the dam alignment and the constructions taken up following a sequence. The first to be tackled is usually the middle one where the river sluice block is normally built. The latter method is known as tunnel diversion. No tunnel diversion was thought of as it is very expensive in this case. Stage diversion method was resorted to taking advantage of the two canal sluices, one on each side of the river course.

The river Vaniar at the chosen dam site runs in cutting which is fairly deep. There is a sudden drop in ground levels as the river margin are approached from the hill slopes at the right flank end - L.S. 1330 m and from the rocky mound (hillock portion) which lies between L.S. 640M and 730M from the left side. The right main canal head sluice was to be located at L.S. 1310 M and the left main canal sluice at L.S. 735M (as per original proposals). The river flows were diverted through temporary shallow channels to be formed across the bund alignment about 40 meters away from these sluices' locations. Leading channels for taking the flows from the upstream side and the guide channels where no deep excavations were necessary to guide the flows to let the flows join the natural river course below are proposed about 65 meters away from the front toe wall sufficiently beyond the clay blanket proposed for the river course portion inside the reservoir and the toe drain on the rear side so that they did not interfere with the formations of the earth dam and rock toe and filters. An arrangement to arrest the flow in the original course a few meters below the off taking points of the above two diversion channels was all needed to complete the river diversion works here satisfactorily plugging of these diversion courses was programmed after the sluices have reached advanced stage of completion and the surplus regulator is raised above crest level. No masonry coffer dam was found necessary in the case of the Vaniar Scheme. The decision to delete the river sluice block shortly after the first inspection of the dam site by the Chief Engineer Irrigation made matters easy in this context. There was no necessity to resort to elaborate arrangements for large scale works of diversion in the case of Vaniar scheme.

12.2 ARRANGEMENTS MADE IN VANIAR SITE

The river course was left untouched until March, 1981. Excavation of cut-off trench and embankment formation upto a small height were going on in the various reaches (of the dam) conveniently away from the river margins on either side. It was during the inspection of head works on 28.02.81. and 10.03.81, that the Superintending Engineer, PWD, Special Projects Circle, Krishnagiri instructed that the cut-off trench work in the river course portion should be taken up immediately and to complete the filling before the on set of monsoon that year. This was an ideal suggestion as the flows in the river during the period March to August would be meagre and dewatering expenses will be minimum and the works can go on with least interruptions due to rain.

12.3 Excavation of the leading channel and outlet channel on the right side to guide the flow in to the existing river course below were started in right earnest in May, 1981. The capacity was almost the river capacity upto summer water level plus 15 percent. As soon as this new course on the right side was ready a ring bund was formed to block the river flow beyond the off take point of the newly dug diversion channel. This ring bund was sufficiently away from the top margin of the cut-off trench for the new high earthen embankment across the river course. This was the deepest portion of cutting. In order to minimise seepage effects the ring bund was formed with good impervious soil and casuarina piles were driven on either side of it to strengthen the ring bund and increase its stability. Its slope was as minimum (as steep) as possible. Horizontal ledgers were tied and nailed to the vertical casuarina piles to increase their effectiveness in retaining the ring bund slopes. This first stage diversion works were completed before June, 1981.

The ring bund on its left joined with the high ground which was the continuation of the hillock and on its right with the guide bund of the diversion channel neatly formed using the excavated earth. The top of this ring formation was above the maximum level of the river flow normally expected during that lean period.

12.4 After the embankment across the river course rose above elevation 460M, the second leading and outlet channel on the left side was formed and the flows were diverted through this new route. This was the second stage diversion. The cut-off trench and embankment formation in the portion of the earth dam where the first stage diversion channel crossed the dam alignment was then taken up and expeditiously completed. The gap left in the earth dam at the crossing of the second stage diversion was plugged after the surplus regulator had reached the crest level and all the works in the surplus course were completed. The two canal sluice barrels were maintained for diversion of small flows as these gaps and the river portion were being plugged. The formation of the canals immediately below the two tower head sluices was put off and taken up after the earth dam was fully formed and the diversion through surplus course became possible

12.5 This arrangement was not entirely fool-proof. There was unusually heavy rains during July-August that year (1981) on July 15th, 16th, and 27th,

the rain fall recorded at dam site was 21mm, 15mm and 44mm respectively. On 25th and 26th August, 1981, the rainfall recorded was 67mm and 46mm respectively. The diversion arrangements failed and the cut-off trenches in the river course portion were flooded, seepages also were heavy. Bailing out water and removal of mud etc. were to be done on a large scale. Two new powerful pumps were brought to site to dewater the cut-off trench base. A short fall of 6,000m^3 upto September, 1981 in the target fixed for cut-off was reported due to these occurrences.

227981
Chennai-600 09

CHAPTER 13
FORMATION OF EARTH DAM

13.1 GENERAL FEATURES

The Vaniar Earth Dam was constructed during the years 1980 to 1984 with a central impervious core with shell zones of semi-pervious materials and a core trench i.e., cut-off trench filled with impervious oil below the central core to a depth of equal to half the reservoir head above the natural ground. The upstream slope is 2.5 horizontal to 1 vertical while the downstream slope is 2.0 horizontal to 1 vertical. The crest width is 3.65m. A drainage blanket connected to rock toe and a toe filter is provided below the down stream shell zone wherever the depth of storage exceeds 3.0m. The upstream slope is safeguarded against rain gullies by turning and masonry and concrete chutes. It carries a road on top with parapets on either side.

D27.2116.V N85 N99

13.2 ESTIMATE PROVISIONS

13.2.1 The scheme estimate technically sanctioned for Rs.616 lakhs provides for the formation of the earth dam for a total length of 1290m. The earth dam including regulator is 1290m. Though the end chainage indicated in the L.S. as 1372m, the reach between Om-82m is high ground, higher than the top of bank and hence the actual length of earth dam is 1290m only. The chainage adopted during investigation was followed without any change. The free board adopted is 2.1m for the reach upto L.S.635 and 3.00m beyond L.S. 725m (vide orders of Chief Engineer (I) the Chief Engineer (I)'s PH/15737/79-15. dt.28.02.80). The Free Board between 630 and 725 is gradually increased from 2.1m to 3m with a gradient of 1/100. The Free Board is increased in the deeper portion taking into account the fetch of the reservoir, the maximum probable wind force, the location of earth dam, nearness to the foot of the hill and other special circumstances. The section of earth dam adopted are as per typical sections furnished by the designs office (vide drawings No.VR.1.02 sheet No.1 & 2).

13.2.2 The water spread area is approximately 270 acres half of which is in Patta lands and half of which is in reserve forest area. The forest department had agreed to hand over the reserve forest lands to the department after removal of the forest growth, plantation etc. The soil availability (suitable for formation) ranges from 1 to 1.25m depth and the soils available in the submersible area was not sufficient for completing the formation of the bund. Total requirements of IPZ and SPZ soils is 12.30 lakhs m³. Therefore additional borrow areas were located below the dam alignment also within 0-1, 1-2 km 2-3 leads. These comprised both Patta lands and forest lands.

13.2.3 The formation of the bund was proposed to be entrusted to TAPWEC (Tamilnadu Public Works Engineering Corporation Ltd - A Tamilnadu Government undertaking) Filling up of cut off trench with impervious soil would be done by lorry conveyance, through contractors, TAPWEC would have to do nearly 10 lakhs m³ of bund formation (volume of finished bund). They proposed to engage two units of heavy earth moving machinery which would require a total

crew strength of about 50. The TAPWEC required the department to provide temporary quarters for them and also to provide sheds for machinery repairs, stores, tool room etc. L.S. provisions were made for these temporary building and other items in this estimate. In the rate for earth for formation of bund 10 percent extra over schedule of rates was provided as allowed in Chief Engineer (I)'s Memo No.A6/3275/76-4, Dated 14.12.77. Tests had been conducted for the dry density of the soil in the barrow pits (IPZ and SPZ) and the maximum dry density which was to be achieved in the bund for IPZ and SPZ and it was found that 13.4 percent extra quantity of soil for IPZ and 19.6 percent extra quantity of soil for SPZ in borrow pit would be required for obtaining the volume of finished bund and these extra quantities were provided for in the estimate.

13.2.4 CUT OFF TRENCH

The cut-off trench was excavated to a depth of D/2 with a side slope of 1/2:1. The soils at various I.S. were analysed through trial pits, excavation and the soil was generally found to be hard. The side slopes will be restricted to 1/4:1 if harder soils like medium rock or dense medium rocks were to be met with some large boulders were also expected to be met with. Sheet rock was not expected to be met with. Provisions had been made to remove these hard rock boulders by blasting wedging splitting etc. The useful stones would be utilised for rock toe etc. The bottom width of cut off trench would be 3m and the sides would be suitably stepped or sloped to key the layers of earth to be filled in.

13.2.5 TOP SOIL REMOVAL

The unsuitable top soil consisting of loss soil organic materials, vegetation, debris etc. would be removed for a depth of about 0.6m

13.2.6 FORMATION OF KEY TRENCHES

Key trenches of size 1.5m x 0.3m at 4.5m intervals would be excavated on the upstream side SPZ to key the bund to the foundation soil.

13.2.7 REMOVING THE HILLOCK PORTION IN THE ALIGNMENT OF EARTH DAM

There is Hillock portion in the alignment of earth dam between a LS 645-730m. The hillock portion lies partly in the IPZ and partly in the downstream SPZ. The hillock comprised large sized hard rock boulders embedded generally in gravely soil. Its permeability characteristics were doubtful and it was considered unsafe to leave it inside the finished earth dam as heavy leakage might develop later endangering the stability of the bund. Hence it was decided to remove the hillock portion even though it was not contemplated in the original scheme estimate. In the revised estimate provision had been made to remove the hillock. This concept was however, modified during execution as explained later. The useful stones available from the removal of hillock would be used for forming rock toe and for metal required for graded filter and thus the necessity of obtaining stones or metal from quarries elsewhere avoided to a large extent.

13.2.8 FORMING ZONED (FILTER ROCK TOE AND TOE DRAIN)

Filters comprising sand and 3/16" to 3" size graded metal be formed. The graded metal would be broken mostly out of the blasted stones available in the removal of hillock portion in chainages between 645-730m. The sand will be quarried from lower reaches of Vaniar river 7 to 8 km below the dam and also from the Meenar river (a tributary to Vaniar) with similar lead. The scheme estimate provided a lead of 4 km only for sand. It had been thoroughly examined and found that sand deposits were available only at 7 to 8 km from the Meenar river and not at 4 km lead as originally contemplated. The extra cost involved would be about Rs. 2 lakhs and found to be inevitable. The extra cost was small when compared the over all cost of the work. The horizontal filters would be formed after dressing the ground to have a slope of about 1 in 50 towards the outer toe to facilitate easy drainage.

13.2.9 The rock toe would be formed by densely packing the stones and filling up the spaces in between with smaller stones duly hammered down as for the formation of aprons. Rock toe would be formed from the hard granite stone available in the removal of hillock portion to the maximum extent possible. For estimate purposes provision was made for quarrying a limited quantity from outside quarries at 1-2km lead. The face of rock toe and toe drain would be finished neatly by providing rough stone revetment 23 cm thick through out. The blasted stones available in the removal of hillock portion would be utilised for the purpose to the maximum extent possible. For estimate purposes provisions were made for quarrying a limited quantity of rock quarried outside with 1-2 km lead. For toe drain suitable gradient (matching with the natural ground slope along the path of traverses) was proposed for the easy flow of water.

13.2.10 FORMATION OF DAM

It was proposed to be got done utilising heavy earth moving machineries of TAPWEC except filling up of cut off trench which would be got done through contractors lorries. The IPZ and SPZ would be formed as per specifications for formation of earth dam ensuring optimum consolidation, with optimum moisture etc. Top soil removal in borrow areas, clearing scrub jungle and light jungle etc. in borrow areas and haul road areas, forming haul roads and ramps were proposed to be done by machineries of TAPWEC and hence extra payment due to the corporation for these additional items were provided for in the estimate. There is an LS provision of Rs.181.0 lakhs towards this work in the sanctioned scheme estimate and Rs.199.10 lakhs in the estimate technically sanctioned by the C.E. (I). The estimate was priced to 1980-81 schedule of rates. The estimate was chargeable to 533 Major-A. Irrigation Projects (Commercial) schemes in Five Year Plan - State Plan Vaniar Reservoir Schemes-JB Dam and Appurtenant work-46 works.

13.2.11 UPSTREAM SLOPE PROTECTION

For the upstream slope of the earth dam, rough stone revetment of 45cm thick was proposed over a 23cm thick base of gravel soil available from the excavation of surplus course as filter bed. Necessary provision had been made for cutting the extra casing soil deposited on the upstream slope of the earth dam for proper consolidation on the edge of bund by power rollers.

FORMING TURFS CHUTES, STEPS, ETC.

In the downstream slope of earth dam turfing was proposed to protect the slopes against rain gullies. Necessary provision had been made for initial fixing of turf. The quarry for turf was located at Venkatasamudram tank with a lead of 4 to 5 km. Chutes were proposed at 20m intervals for easy drainage of water from the bund. Necessary provision had been made for constructing steps at convenient places. For estimate purposes chutes were proposed with random rubble masonry in cement mortar 1:5. During execution it might be suitably designed as pre-cast RCC trough or other suitable type.

13.2.12 FORMING ROAD ON TOP OF BUND

On top of bund black topped surface road was proposed over two layers of metalling. Parapet walls were proposed in random rubble in cement mortar 1:5. Necessary provision for RC coping ornamental finish, turn circles and entrance arches were also made.

13.2.13 DIVERTING THE RIVER COURSE DURING EXECUTION

For diverting the river course, normally construction sluices or river sluices are utilised. As the river sluices were omitted as per the instructions contained in CPI No.P4/15737/76-6. dt. 25.09.79 two diversion channels were proposed. First stage diversion course crossing the bund at L.S.1160 m was to function during June 80 to December 81 and the second stage diversion course at LS 630m to function during January 82 to January 83.

Working estimates for all the above sub-works were prepared and enclosed.

13.2.13 NECESSARY LUMPSUM PROVISION WERE MADE IN THIS ESTIMATE FOR THE FOLLOWING ITEMS:

1. Special treatment to the hillock portion on the R.F. end. including excavation and construction of core walls if necessary.
2. Formation of haul roads including matamtaining and watering.
3. Providing bank connections and tanks ramps.
4. Bailing out water from cut-off trench during excavation,
5. Providing temporary pipe line connections.
6. Fixing V notches in the drain and outlets.
7. Cost of temporary shed for material and rest shed. working details enclosed)
8. Supply of water for works and labour.
9. Soil testing laboratory equipment and conducting field tests.
10. Electrification arrangement during emergency works.

11. Chipping weathered rock and coffer dam and providing steps for movements of labour whenever necessary.

12. Provision of alternative graveyard to the R.F. area above the FRL contour as the existing road now being used would be submerged.

13. Unforeseen and miscellaneous works.

14. Contingencies.

DESIGN CONSIDERATIONS

The basin, parameters and approaches adopted in the design of the earth dam of Vaniar Reservoir project are detailed below:

SOIL PARAMETERS

The soil samples taken from the places indicated by the field staff of the Soil Mechanics and Research Division mostly in the reservoir water spread area, were got tested in the SM & R Laboratory, Chepauk and the values were tabulated. The design shear parameters were so selected that 75% of the actual test results are above the design value that was finally adopted. This condition satisfied the I.S. Code for stability analysis of the earth dam vide para 4, page 6 of IS:7894 of 1973. The design procedures generally conformed to the minutes of the discussion communicated in the Chief Engineer, Irrigation, letter No.DB/HD/4381/77-14 dated 08.08.77.

On these considerations, the following parameters chosen from the test results as stated above were adopted in the design of earthen embankment of Vaniar Dam.

Sl.No.	Casting Zone	Soil Parameters	Heating Zone
1.	Optimum Moisture Content	12%	12%
2.	Maximum Dry Density	1718 kg/^{3}	2060 kg/^{2}
3.	Cohesive Strength	2237 kg/^{3}	2012 kg/^{2}
4.	Angle of Internal Friction	21 deg.	32 deg.
5.	Specific Gravity	2.64	2.83

The following hydraulic particulars were adopted for the earth dam section:

T.B.L.	E.L. 473.10 m
M.W.L & F.R.L.	E.L. 471.00 m
Deepest Bed Level	E.L. 441.00 m
Maximum Height	32.00 m
Normal Bed Level	E.L. 452.10 m
Normal Height	21.00 m
Top Width	3.65 m
Top Width of I.P.Z.	2.50 m
Level of top of I.P.Z.	E.L. 471.90 m

STABILITY ANALYSIS OF EARTH DAM SECTION

The stability of the proposed upstream and downstream sloped of the section of 21 m height and the deepest section of 32 m height of earth dam were checked by Swedish method. The stability analysis of down stream slope had been done taking the room toe into consideration as outlined in para 9.3 of I.S. Code for stability analysis of earth dam.

For the downstream slope, 2 to 1 slope with 1.5 m width of berm at every 6 m height from top was found to be safe. Two separate sections one for a height of 22 m of earth dam and another for a height of 32 m earth dam were tried. For the deepest section 4 trials in each for upstream and downstream slopes were done. The downstream slope was fixed based on these 4 trials for the deepest section. For the other section of 21 m height, six trials were done and the slope of 2 to 1 was found to be safe.

For the upstream side, first a 2 to 1 slope throughout was tried, but found to be unsuccessful. Hence for typical section of 21 m height for the first 12 m height from top a 2 to 1 was adopted and found to be suitable. For the deepest section of 32 m height a section of 2 to 1 slope for the first 12 m from top a slope of and a slope of 2.5 to 1 for the remaining height of 20 m was tried first. This was found to be unsuitable. Hence a revised section of 2 to 1 slope for the first 12 m height from top and a slope of 2.5 to 1 for the next 9 m and 3 to 1 slope for the remaining 11 m height was tried and found to be safe. The values of factor of safety worked out for the upstream and downstream slopes are tabulated below:

Trial No.	Downstream		Upstream	
	Section of Height 21 m	Section of Height 32 m	Section of Ht. 21 m	Section Ht. 32 m
I.	2.1123	1.6297	1.20(Unsafe hence slope revised)	1.23(unsafe hence slope revised)
II.	1.9036	1.6650	1.294	1.28
III.	1.8258	1.6672	1.295	1.28
IV.	1.8784	1.63.50	1.290	1.27
V.	1.7890	-	1.280	-
VI.	1.8330	-	1.215	-

13.3 WORKS STARTED PRIOR TO TECHNICAL SANCTION

13.3.1 The first Major component of the scheme, the earth dam was taken up by the field Executive staff of V.R.P. in right earnest and at the right time, with-

out waiting for the procedural formalities to be gone through in all respects. The work was commenced without any technically sanctioned estimate by the competent authority. The best working season in this region is from January/February to June/July. This was taken advantage of for showing good progress. The division staff did take actions to submit the estimates for sanction in time. The preliminary requirements for obtaining technical sanction in time. The preliminary requirements for obtaining technical sanction to the working estimate for the earth dam were completed well before March 1980. Spot levels for plotting the longitudinal and across-sections of the earth dam were taken during August-September, 1979, very soon after the technical staff joined duty and the subdivisions and the division started functioning with basic facilities. Detailed and abstract estimates for this component had to be got ready after necessary field tests for classification of soils and also after carrying out the necessary design modifications in consultations with the Superintending Engineer Designs Circle, Madras. Also the project staff had to wait till after April that year for the schedule of rates for the financial year 1980-81 to be approved. The earnest and positive efforts taken by the Executive Engineer, V.R.P. and others in arranging to fix reasonable and workable rates for the various items of earth works are detailed in Chapter 10. The working estimate for Rs.304 lakhs for the earth dam was submitted to circle office in August, 1980. The works had already been in progress by then.

13.3.2 The fact that the field staff at the Vaniar Dam site were going ahead with the work of formation of earth dam was duly intimated to the higher authorities including the Accountant General, Madras. A reference dated 18.06.80 sent by the Superintending Engineer, PWD, Project Circle Krishnagiri to the Chief Engineer, irrigation in this context vide Annexure explains the urgency for going ahead with the works of Earth Dam formation in anticipation of sanction by the Chief Engineer. The expenditure in the divisions accounts was represented as that incurred under want of estimate and the same got regularised later when the estimate was duly sanctioned and registered.

13.3.3 PROPOSAL TO INCREASE THE HEIGHT OF BUND - NOT PURSUED

As per hydrology in the report of the sanctioned scheme, the yield available from the catchment at the dam site was worked out to be 31.2 M^3 (1098 m.cft) But for the new ayacut of 8550 acres - irrigated dry - and stabilisation for the old ayacut of 1852 acres a quantity of 33.8 M^3 836 M.cft) could be adequate. This left a balance of 7.4 M^3 (262 M.cft) as surplus; since the reservoir capacity was fixed as 11.9 M^3 (418 M.cft) and two fillings per annum only were contemplated, this balance of 7.4M^3 (262 M.cft)would go unutilised. Further the working table prepared for the proposed irrigation indicated that the scheme would be successful in 26 years out of 27 years considered. At this initial stage of implementation of the project it was thought fit to enlarge the scope of the scheme. The fact that the available untapped water resources of the State as a whole was becoming less and less encouraged this line of thinking.

Though 75% success of irrigation under a scheme is generally considered adequate for taking up the scheme for execution for a water starved State

like Tamilnadu, it was expected that even 50% success could be considered as a criteria for sanctioning a scheme. This being the case, the proposal envisaging 96%. Successful irrigation would mean a definite under utilisation of the available water resources. Based on this line of argument a preliminary investigation was done and a report was submitted to the Government, PWD, in Chief Engineer's letter No.P4/15737/79-36, dated 05.08.80 that it would be possible to expand the new ayacut under this scheme by an extent of 1660 ha. (4100 acres) by increasing the height of the dam by 3.05 m (10 ft.) to hold a capacity of 16M^3 (564 M.cft) against the original 11.9 M^3 (418 M.cft.). The length of the canals would be increased and this interim proposal would require an additional acquisition of 121 ha. (330 acres) of forest patta and poromboke lands. The cost of this enlarged scheme worked out to Rs.1240 lakhs as per 1980-81 schedule of rates.

Subsequently in Chief Engineer (Irrigation)'s letter No.68625/80-1 it was ordered that the proposal for raising the height of Vaniar Reservoir by 10 ft. over the existing RFL of 471 m (1545.35 ft.) was withdrawn.

13.4 CONSTRUCTION OF EARTH DAM

13.4.1 TOP SOIL REMOVAL AND KEY TRENCHES EXCAVATION

The top soil consisting of vegetation and its roots debris, rubble and loose materials was removed to form a good uniform and firm surface suitable for bearing the heavy load of the proposed Earth Dam and also to lay the filter bed on the downstream side of the Earth Dam. The work of top soil removal up to a firm base below the embankment was started in April 1980 first in the reach 300 m - 600 m and 1100 m - 1290 m. In order to have a good bond between the embankment and the natural ground, key trenches of size 1.50 m x 0.3 m have been provided at 4.5 m intervals under the upstream side semi-pervious zone of bund

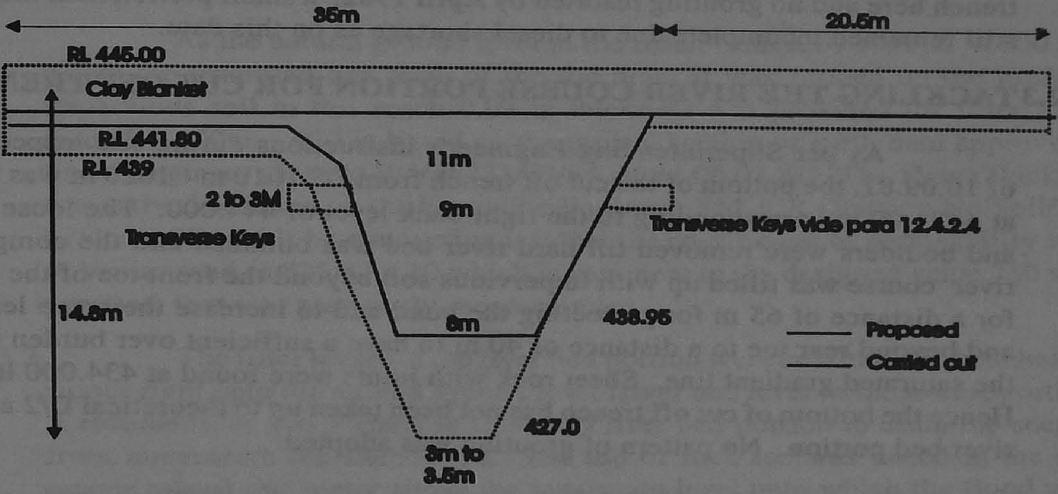
13.4.2 EXCAVATION OF CUT OFF TRENCH

13.4.2.1 The excavation of cut off trench is quite essential to arrest the seepage of water through the interface between old natural soil and newly formed bund and also reduce it by increasing the length of its travel. The depth proposed for excavation is D/2 with side slope 1/2:1. The bottom width of cut off trench is 3 m. the work of cut off trench excavation was also started in April 1980 in the reaches 300 m - 600 m and 1100 m - 1290 m.

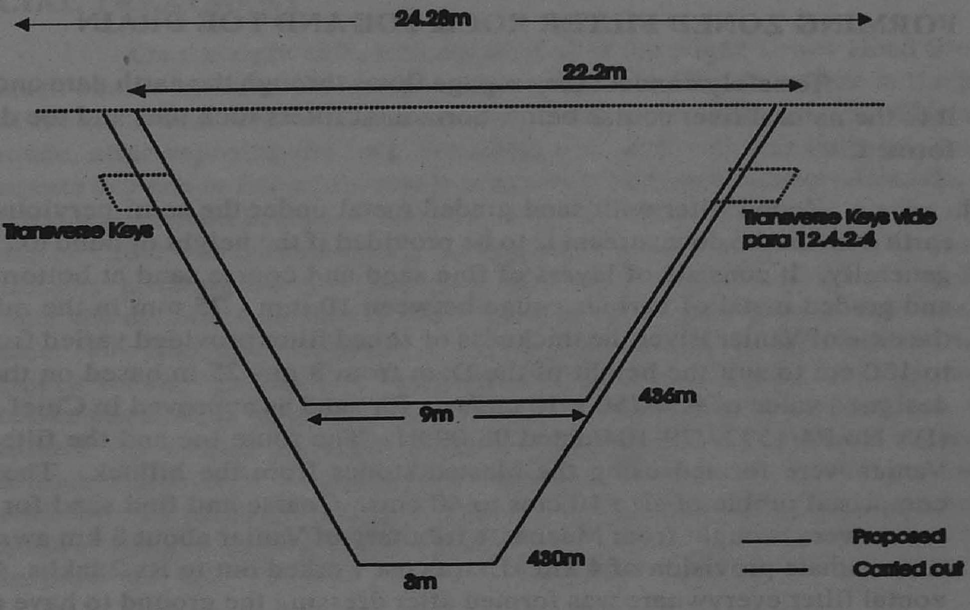
There is a sudden drop of 10 m in the ground level between L.S. 1020-1030 m due to the presence of river course. The ground level at this point which is EL 451.11 m at LS 1020 m falls suddenly to + 441.80 m at LSM 1030 m. In this portion the adjoining right bank level and cut off trench bed level were at 444.000 and 431.000 respectively and the complete river course is filled up with impervious soil beyond the front toe of the dam for considerable distance.

13.4.2.2 RESTRICTIONS IN DEPTH OF CUT OFF TRENCH

Sheet rock was met with in the cut off trench excavation opposite to the mound in thee reach LS 670 - 770 m at shallow depth. Therefore, excavation



CUT-OFF TRENCH AT L.S. 1030 M.



CUT-OFF TRENCH AT L.S. 1010 M.

has not been done down upto D/2 level due to the presence of sheet rock. Key walls to a maximum length of 25 m in R.R. masonry in C.M. 1:4 0,45 m thick and 1 m height over a bed of CC 1:5:10 0.20 m thick were provided wherever rocky strata were met with. No grout holes were drilled from the base of cut-off trench here and no grouting resorted by April 1982. a small portion near hillock still remained incomplete due to diesel shortage as on this date.

13.4.2.3 TACKLING THE RIVER COURSE PORTION FOR CUT OFF TRENCH

As per Superintending Engineer's instructions during site inspection of 10.09.81. the bottom of the cut off trench from LS 1010 m - 1020 m was kept at +431.00 m corresponding to the right bank level of 444.000. The loose soil and boulders were removed till hard river bed was obtained and the complete river course was filled up with impervious soil beyond the front toe of the dam for a distance of 65 m for protecting the bund and to increase the creep length and beyond rear toe to a distance of 40 m to have a sufficient over burden over the saturated gradient line. Sheet rock with joints were found at 434.000 level. Hence the bottom of cut off trench has not been taken up to theoretical D/2 at the river bed portion. No pattern of grouting was adopted.

13.4.2.4 Excavation and filling the cut off trenches in the small portion near the hillock and in the river bed portion were completed by September, 1982 in all respects as per B.F.P.R. notes. The bed width of the cut off trench was 3 m - 3.5m in the reach 1020 - 1030. Two cut off trenches of 2 m width at bottom inside and 2 m below the ground level were taken well into the sides at least 2 m below the ground level were taken well provided at chainages 24 m upstream and 75 m upstream for proper keying of the impervious soil that was being filled in the river portion with the side slopes.

13.4.3 FORMING ZONED FILTER ROCK TOE AND TOE DRAIN

To safely conduct the seepage flows through the earth dam and leading it to the natural river course below horizontal filters rock toes and toe drains are formed.

13.4.3.1 Zoned filter with sand graded metal under the semi-pervious zone of earth dam on the downstream is to be provided if the height of bund exceeds 8 m generally. It consists of layers of fine sand and course sand at bottom and top and graded metal of various gauge between 10 mm - 75 mm in the middle. In the case of Vaniar River the thickness of zoned filter provided varied from 40 cm to 150 cm to suit the height of the Dam from 8 m - 25 m based on the usually designed value of K = 750 x 10 cm/sec. for sand as approved in Chief Engineer (I)'s No.P4/15737/79-104/dated 08.09.81. The route toe and the filter zone in Vaniar were formed using the blasted stones from the hillock. The rock toe comprised rubble of size 10 cms to 40 cms. Coarse and find sand for the filter zones were brought from Meenar, a tributary of Vaniar about 8 km away against the estimate provision of 4 km. Extra cost worked out to Rs.2 lakhs. The horizontal filter everywhere was formed after dressing the ground to have a slope of 1 in 50 (transverse) towards the outer toe to facilitate easy drainage. Rock toe

was formed by densely packing the stones 423 cms thick stone revetment was provided on the outer faces of both rock toe and drains.

The details of this filter works and the zoned sections formed in the various reaches of Vaniar Earth Dam are shown in the tabular statement.

As the natural ground level in the reach from L.S. 1040 m - 1200 m is below the proposed bed level of the toe drain it was formed on the made up impervious soil in this reach 0.09 m thickness was provided for filter in the reach LS 400 m - 620 m based on the typical section of earth dam approved in Chief Engineer (I)'s No.P/4/15737/79/64 dated 06.02.81. The above thickness was arrived at based on the Executive Engineer, SM & R Division No.Soil/321/81/dáted 07.11.81. by conducting test that the co-efficient of permeability value of Vaniar sand as 825.87 x 10 which is very near to the designed value 750 x 10-4cm/sec. that was previously recommended.

13.4.3.2 The filter layers in the river bed portion were continued in benches and slopes right upto the natural ground level (river bed level in the lowest portion). A reverse filter was formed in this deep river bed portion to drain the seepage from underneath the foundation. The top of rock toe was raised in the deep course atleast one meter above the maximum level upto which the flood water are expected to back up in this region. At the river portion beyond rock toe a bund with 6 m top width and with a pipe culvert beneath to pass the toe drain water has been formed to serve as toe drain inspection road which runs parallel to the toe drain along the entire length of the earth dam on the downstream side. As per B.F.P.R. notes the achievement in respect of filter formulation was 56% till August, 1982.

13.4.3.3 EARTH DAM ROCK TOE AND DRAIN AT RIGHT FLANK END - SPECIAL TREATMENT

On the right side, immediately after the Right Tower Head Sluice, the earth dam is abutting the steeply sloping hillock. The treatment at the junction of the earth dam and the hillock was carefully done. After the cut off trench was made, after exposing the rock available, a cut-off wall was built to provide adequate key one or two additional key trenches were also excavated and the earthen bund was formed in layers extending into the mountain slope. At the upstream side, a chute was created at the junction of the earth dam and the hillock slope by suitably grouting the revetment portion for a width of 2.0 m and the drainage from the mountain slope was led into the toe drain guided by a dwarf wall along side. The leading channel to the right sluice is close to the hillock. All loose stones above this channel were removed so that they may not slip down and choke the leading channel. The slope of the earth dam at its junction with the hillock (mountain) here, has been eased in such a way that the recess in the hillock slope down stream is fully covered. There was a small increase in the rock toe and the earth dam section in this short right flank end reach; but it was quite necessary seeing the location. And the Chief Engineer, Irrigation in his inspection notes allowed these extra provisions.

13.4.4 HILLOCK IN THE ALIGNMENT - DIFFICULTIES ENCOUNTERED

13.4.4.1 There is a hillock portion in the alignment of earth dam from LS 645 m - 730 m. This mound portion was first considered to lie partly in the IPZ and partly in the downstream SPZ of the Earth Dam. The earlier impression was that the hard rock in the mound was not a continuous sheet rock as many numbers of fissures and cracks were noticed in the rocky formations of the mound. Hence the removal of this mound was thought essential so that a compact homogenous earth dam can be constructed. After nearly 50 percent of the hillock was removed and the blasted stones advantageously used in the formation of filters and rock toe works, it was noticed that the left out portion of the mound largely fell outside the central impervious core. Hence further blasting works were immediately stopped. By that time it was established that the rock exposed was sound and continuous. A surface of hard casing portion after roughening of the surface and chiselling and dressing it to slope towards the toe drain. In the portion where the rock extended into the hearting zone R.R. masonry cut-off walls in cement mortar 1:5 for 45 cms thick and 1.0 m height were constructed parallel to the dam line at 5 m intervals on the rock surface for properly keying the embankment with the hard fresh rock surface. In this hillock portion, regular filter media for full width could not be formed. Therefore the following special arrangement was made to drain the water seeping through the dam section.

13.4.4.2 Instead, a trench filter with loosely joined perforated pipes with gentle slope towards one end to drain the water into the toe drain was formed beyond hillock. The pipes were fully covered by the rock toe. The drain water from LS 400 m - 660 m i.e. upto hillock (as it could not be continued beyond the hillock) is let into the surplus course by means of connecting drain.

13.4.5 AGENCY FOR FORMATION OF EARTH DAM

13.4.5.1 About 104 lakhs ^{3} of (consolidated) earth work was required to be done. Major portion of this work was proposed to be done with heavy earth moving machineries of the Tamilnadu Public Works Engineering Corporation (a Government undertaking which was later abolished and merged into PWD and made a department again from 01.04.82). Negotiations with them were started as early as October, 1979. Rates for the various items of the work quoted by them were examined and their conditions for undertaking the work were also considered and discussed with higher authorities. As better quality of work can be turned out by machineries and as the progress also could be faster, an excess of 10 percent over the corresponding schedule of rates were allowed in their favour. Chief Engineer (I) had also permitted this extra payment.

13.4.5.2 The TAPWEC, planned to engage the following staff, crew and machinery to achieve the target of over 10 lakhs cubic meters of earth in embankment in 3 (three) seasons:

		Nos.
Scrappers	:	12
Dozers	:	6
Lorries/Water Tankers	:	4
Assistant Executive Engineers	:	2
Assistant Engineers & Junior Engineers	:	4
Assistant and Junior Assistants	:	4 (2 in each category)
Basic Servants	:	2
Operation and Maintenance crew	:	80

Two sets were programmed to be operational throughout in two shifts per working day.

To start with 6 (six) scrappers and 2 dozers only were pressed into service. About half the above strength of personnel only arrived at dam site by the 3rd week of June (20.06.1981) and the machinery started working on 10.07.1981. Quarters for the key personnel besides sheds for repair and maintenance yards and a diesel bunk were made ready expeditiously. More units of earth moving equipment reached subsequently after diversion from the projects which were nearing completion. All the items were not new and the units had been in use for sufficiently long time before. Hence break downs were fairly common. Service facilities at dam site took time to become fully operational.

Being an interdependent job the embankment formation in Vaniar Dam had to be put up with certain interruptions. A few of them were unavoidable. There were breaks in the progress of raising up the bund by machinery in the sections where masonry components of the dam and the temporary diversion channel crossed the bund alignment. Rock toes filters and toe drains were not completed sufficiently ahead in few reaches making way for the machinery to move in. To add to the difficulties there were diesel shortage and power cuts. Certain sections of the earth dam had to be set apart for the private agencies who were already engaged in the construction works in dam site in order to see that their work force which would otherwise be idle were provided for on humanitarian considerations. Instances of such slippages were mentioned later in this chapter.

The Corporation had insisted accommodation for their operating crew in the dam site for which however, at a later stage some percentage deductions were made in their claim bills for works

turned out. The cost of transport of machinery had to be borne by the project division. Supply of diesel at market rate was arranged by the Department and the cost was recoverable. The weekly requirement was 3,000 liters and a repair yard was also provided.

13.4.5.3 The entire quantity of earth works in the embankment was not actually carried out by TAPWEC. The machineries went sick and there was diesel shortage more over the local contractors who were engaged in doing surplus regulator and other components were pressing that a portion of this huge work should be given to them as some of their labourers were idle due to reasons beyond their control. Their request had to be complied with to a certain extent. It was also reported that they brought in political influence to back up their demand.

13.4.5.4 An amicable settlement was arrived at. Accordingly the embankment formation across the river course along with the rock toe was assigned to private contractors. The level to which they should do the work was fixed at 453.0 m. Above this level it was agreed that the machineries can take over. In the river course portion, the work up to elevation. 447.5 m was proposed to be done by the private agencies and the balance was to be done by TAPWEC. (Note: The stages of progress and slippages in forming the earth dam are separately furnished).

13.4.5.4 THE RATES FOR EARTH WORKS BY MACHINERY BY TAPWEC WERE FIXED AS FOLLOWS:

Unit rate to be adopted for the earth moving jobs using machinery with effect from 01.04.1982 was generally the prevailing schedule rate at the locality plus 10% extra. It was also instructed that the quantity to be arrived at for the purpose of payment will be actual compacted quantity plus 15% for swell - as in the case of machineries it is not possible to assess the borrow pit quantities correctly - vide C.E. (i) Memo No. a6/35856/82-3 Dt.11.01.1983.

A data was worked out based on the above, instructions as noted below:

Earth work excavation and depositing in embankment using machineries - with initial lead of 10 m and lift of 2 m in soils suitable for I.P.Z. and S.P.Z. of earth dams with the following leads, unloading and forming the earth dam on layers of 23 cms thick complete as per S.S. 20 A for $1m^3$

	LEADS		
	0 to 1 km	1 to 2 km	2 to 3 km
Earth work hard soil as per S 20 A at Site	3.30	3.30	3.30
Incidental Charges	6.09	6.09	6.09
Lead cost at 1045 per km	1.46	2.92	4.38

Unloading charges	2.00	2.00	2.00
Sub-Total	12.85	14.31	15.47
Add 10% extra for machinery	1.29	1.43	1.58
Sub-Total	14.14	15.74	17.35
Rate for 1m³ Considered quantity	x115/100	x115/100	x115/100
Deduct Rs.1.60 per m³ for providing amenities	16.26	18.10	19.95
Final Rate	14.66	16.50	18.30

However, the Chief Engineer, Irrigation in his letter No.03/61151/81-82 dt.18.09.1981 approved the following rates for earth work done by machinery by TÁPWEC for the periods mentioned.

		FOR LEADS		
		0 to 1 km	1 to 2 km	2 to 3 km
i)	From 11.07.81 on wards rate per m³	14.20	16.70	21.20
ii)	With effect from 01.04.83	18.30	20.34	22.08

Note: Deduction for amenities provided was not mentioned.

13.4.5.5 After removal of top soil, excavation of key trenches cut off trenches and filling the same with good impervious soil and after the formation of the rock toe and filter on the downstream side by private agencies the formation of earth dam by machinery was taken up in the middle reaches to start with. The formation of Earth Dam mainly consisted of quarrying conveying, spreading and consolidating the earth suitable for impervious and semi-pervious zone layer after layer each generally not exceeding 23 cms. Consolidation of these layers was done by power rollers. No sheep-foot rollers was used. Compaction was started from the farthest end each side and the rollers moved to the centre of the earth dam. Each lateral shift was equal to half the width of the roller. The thickness of each layer was kept little depressed at the centre. The process of compaction was constantly supervised by the soil laboratory staff who were stationed at the dam site. The number of runs of the 10 T diesel rollers for each layer in a stretch was determined by trials with reference to the nature and moisture content of the soils in the specified borrow areas, The IPZ was compacted at optimum moisture content to the maximum dry density. The shell zones were adequately consolidated to provide stable support for the impervious core under various conditions of saturation and draw down. The impervious zones were formed upto a saturation abd draw down. The impervious zones were formed upto a level of +471.90 m i.e. 0.9m above FRL with a top width of 2.5 m and the side slope of 1.1 everywhere. The counter part of this impervious zone viz., the cut off trench which is below ground level had already been filled with the same impervious soil.

13.4.6 BORROW AREAS FOR DIFFERENT SOILS - FIXED

13.4.6.1 Field tests were conducted in reservoir water spread (R.F. area) and outside and the places where the two kinds of soils one for impervious zone and

the other for semi-pervious zone - were available with their depths were identified and their boundaries clearly marked. The machinery crew were given definite instructions to take the required category of soils when needed only from these places and dump them in the respective zones. The supervising staff was asked to watch these operations closely and carefully and ensure that the right types of soils only was brought always for forming the shell or central core zones.

13.4.6.2 As per the test results of the soil taken from the borrow area it was found that 1.134m³ of soil is required to get 1m³ of compacted impervious zone. To protect the clay in the impervious zone from cracks due to exposure to hot sun casing the same with semi-pervious soil containing higher percentage of sand was formed. As per test it is found out that 1.196m³ of soil is required to get 1m³ of compacted semi-pervious zone. Some available references relating to the soil tests are annexed.

13.4.7 DIESEL SUPPLY ARRANGEMENTS

For the supply of diesel to the heavy machineries the diesel bunk at Pambar Reservoir site was shifted to Vaniar Reservoir project site by remitting an amount of Rs.13,750 by D.D. to IOC, Madras.

For the installation of Diesel Bunk at Vaniar Reservoir project site an application with the following particulars was sent to the Divisional Manager Indian Oil Corporation Ltd., Marketing Division, Post Box No.3767, Kamaraj Road, Red Hills, Coimbatore - 641 018.

1. Site Plan	-	1 No.
2. Name of Village and Taluk in which the Bunk has to be installed		- Mullikkadu Village Harur Taluk
3. Survey number of the site	-	362
4. Letter of undertaking	-	We are agreeable to lift 30,000 litters of diesel per month failing which Indian Oil Corporation will be free to decommission and pump at once.

5. The Divisional Manager, Indian Oil Corporation has enclosed two copies of the lay out plan showing the proposed location of the high speed diesel consuming pump facilities at dam site, one plan was signed in token of our approval and returned to him. The divisional manager had made out and sent nine copies of the plan with a request to send two copies of the layout of HSD consuming pumps to the controller of Explosives South Circle, Sastri Bhavan, Madras - 6 for according approval and two copies to the Collector of Dharmpauri for issue of no objection certificate.

6. The District Revenue Officer, Dharmapuri has called five copies of the plan with application in Form VIII in duplicate (Form VIII available with Indian Oil Corporation, Coimbatore), further no objection Certificates are to be obtained for the installation of the bunk from District Health Officer and District Fire Officer besides District Revenue Officer.

7. An application Form VIII under petroleum Rules 1976 in duplicate with Demand Draft for Rs.10/- towards security charges and approved site plan was sent to the Controller of Explosives, Madras.

8. (i) A demand draft for Rs.80/- drawn in any Nationalised Bank in favour of Deputy Chief Controller of Explosives, Madras payable at Madras, Rs.75/- towards licence fee and Rs.5/- towards authenticated copy of licence).

(ii) Pressure test and safety certificate in the prescribed proformas.

(iii) No Objection Certificate in original from the district authority with a copy of the site plan attested by him.

(iv) Three copies of the approved plan.

9. The pressure test and safety certificate in the prescribed proforma issued by Indian Oil Corporation, Coimbatore were sent along with the above particulars and licence obtained and the bunk was commissioned.

10. The indent for supply of diesel was to be placed under D.G. S & D rate contract. The Executive Engineer, PWD had previously should include his name as Direct Demanding Officer by addressing the Director General of supplies and disposals. Parliament Street, New Delhi for procuring all types of material under rate contract basis. Unless the Executive Engineer is declared DDO by DG S & D he could not place supply order under rate contract.

13.4.8 UNIFORM CONSOLIDATION - EXTRA WIDTHS OF SHELL ZONES

While consolidating the earth layer spreaded by heavy machineries by the road roller it was practically impossible to move the roller upto the edge of the embankment. In order to get proper consolidation of designed section of the embankment the same was formed with extra width of about 1 m on either side than that of the designed section at every level. The top level of the bund was kept well below the TBL so as to accommodate the quantity taken out from the extra width of the earth section and deposited on the top of the formed bund manually. Thus no part pof the earth cut from the slopes of the bund was wasted. As the cutting of extra width was done by other agency the same was got approved by the Superintending Engineer.

13.4.9 CLAY BLANKET IN THE RIVER BED PORTION FRONT

The heavy earth moving machineries formed the bund in the reach 400 to 620 m upto ELN. 469.00 by February, 1982 and the machineries were diverted to the reach in between LS 750 - 1000. This was the river course portion. The unsuitable earth in the deep river bed portion were removed during 5/82. The removal of slushy soil muck and boulders was continued till hard stratum (in the river bed portion) was met with in the month of August, 1982. Stable side slopes were maintained so that no slips occurred. This portion was tackled after diverting the flow through the newly excavated channel. This is the deepest point with the largest head of water - about 32 meters. Also this portion was serving as the river course for a long time. Special precautions were therefore necessary to prepare the foundation for the earth dam in this reach and also provision of a hearting of enough width which should extend on the upstream side with a sufficient layer of clay blanket was considered essential. These were introduced accordingly and the clay blanket extended for 65 meters upstream from the toe of the bund here. Care was also taken to key the earth formations and the steep slopes of the bank on either side. Besides the cut off trench which was already excavated and filled in, two more key trenches one on the upstream and one on the downstream side of the cut off trench were formed and these keys penetrated into the side banks for 2 meters at suitable locations.

13.4.10 FILTER, ROCK TOE ON THE REAR SIDE IN THE RIVER COURSE

The filer zone and the rocky toe were continued across the deep river course in benches and slopes right upto the natural ground level - namely the river bed level in the lowest portion in the rear (downstream) side for the filter layers to perform their function satisfactorily. The reverse filter was also essential particularly in this deep reach to drain the seepage through the foundation. The layers of this filter media were formed accordingly with benches and slopes at an incline of 1 in 15 here. The rock toe was however, raised in this deep reach 1 meter above the maximum level upto which the flood waters were expected to back up here in this region. Besides rock toe additional material was dumped in the river course on this downstream side for 50 meters beyond the rock toe and toe drain using the large amount of excavated spoils available at site. This riprap dumped would keep the flashes of the flood water far away from the rock toe of the earth dam. Since the duration of the flood flow is usually short, this would not interfere with the functioning of the toe drain. The seepage outflow from the filters and toe drain would continue during non-flood days, To have a measure of the toe drain flows, cross drains with measuring devices were provided on either banks isolating the flow that occurs in the deep course. The Superintending Engineer had to make frequent visits to the dam site to guide the formations in the deep bed portions.

13.4.11 MACHINERY WORKS RESUMED

By the time the filling of cut off trench and forming a clay blanket in the river portion were completed, the filling of cut off trench in the right flank beyond the diversion channels was also completed and from 9/82 onwards the machineries were diverted to work in this reach (i.e.) 1200 m, 1300 m. However, the machinery could not work here continuously. Due to power cut from 10/1982 to 2/1983, no cement could be obtained from the factories, masonry work came to a stand-still. To avoid hardship to contractors and laborer who would otherwise be idle, bund formation works near the flanks sides of sluices and surplus works were entrusted to the contractors and were carried through lorry conveyance instead of machinery.

As soon as the bund was raised to a safe level in the right flank the machineries were diverted to work in the reach in between LS 620-750. However, the machineries could not be allowed to work continuously in this reach and also at 1300 m since RCC barrels and columns above lateral and longitudinal braces are to be constructed for left and right side tower head sluice and these works were done along with the raising of the bund. The machineries could not go too near the RCC structural members. The portion of each bund around the column braces had to be consolidated manually. While laying and curing concrete the machineries were diverted to work in other reaches.

Four units of heavy machineries (inclusive of stand-by (spare unit) were pressed into service in formation of Vaniar Earth Dam. In Chief Engineer (I)'s No.A6/38586/82-3 dated 11.01.83. instruction was issued that the rate of earth work done by the heavy machinery at prevailing schedule of rate +10 percent. To arrive at the quantity for payment 15 percent for swell over and above the actual compacted quantity was adopted. The quantity of work done by the heavy machineries was assessed on level basis each month and also compared with the trip sheets of the machinery worked.

Finally the work of formation of Earth Dam by heavy machinery in closing the river bed portion was completed on 10.08.84 and the bund level reached +472.00 m level and with this the formation of Earth Dam to the entire length by heavy machinery was completed. As per Superintending Engineer's instruction in No.3153/82/T10/F51/dated 02.11.92. thirty centimeters extra over the top of bund above TBL was allowed for the Earth Dam as shrinkage (and subsidence).

The filling of cut off trench was done with the help of contractor's lorry (as heavy machinery cannot ply with in the trenches) and watering and consolidation were done departmentally. This involved above 76000 ^{3} (compacted volume).

The formation of the Earth Dam by and large except the small portions explained above was done by heavy machinery. The work lasted for three years roughly from 7/81 to 8/84. On average every day two units that is six scrappers and one leveller and two pushers were working doing about 2000 M^3 daily or 40,000 ^{3} every month. The capacity of each scrapper is 13 ^{3} and it made 30 trips maximum a day.

Two shifts were worked. First shift was from 6.00 A.M. to 12 Noon and second shift from 12.15 PM - 3.00 P.M. Then servicing was done in the afternoon.

Due to establishment of a repairs shop all the repair of the machineries were attended to then and there. Idle time and sickness periods for three units were much reduced. However, there was scarcity of diesel in April, 1983 and work was held up for one week continuously.

13.4.12. JEDDY STONE REVETMENT

About 27,000 ^{3} of jeddy stones revetment were done. This was taken up side by side while the formation of the earth bund by heavy machineries was in progress. Very soon after the extra width formed on the upstream side was cut and conveyed and deposited on the top of the bund, the work of laying gravel bed (backing) for this stone revetment was taken up. This was done in stages without waiting for formation of bund to full height.

The slope was trimmed neatly. Then a layer of 25 cm thick of gravel or quarry rubbish was applied. Then jeddy stone dry packing revetment of 450 m thick was done after a toe wall of 0.9 m x 0.70 m was built to retain it. Jeddy stone revetment was provided from LS 280 m - 1360 m and rough stone revetment of 300 m thick was provided in the reach 160 m - 280 m where the height of the bund is small. This jeddy stone revetment will protect the bund from wave actions of reservoir water spread and will also prevent formation of rain gullies. As per Superintending Engineer's No. 2553/F208/AEI/dated 28.08.82 no construction joints have been provided in the revetment on the front face of the Dam.

13.4.13 TURFING AND CHUTES

To protect the rear slope of the Earth from rain and wind erosions and to retain the designed section turfing was done after cutting the extra width formed by the heavy machinery on the rear side and depositing the same on the top of bund. This was also done in stages. The slope was trimed neatly to receive the turf with initial watering.

Chutes with a section having top width 50 cm bottom width 30 cm and height 23 cm in CC 1:3:6 using 20 mm jelly and 15 cm

thick was provided at every 30 m intervals to drain the rain water from the top of bund. Suitable lugs at 4 m intervals were also provided. The inner side is rendered smooth by plastering the concrete chute surface with CM 1:3. Horizontal cross-drains were also provided at the berm at EL 456.000, 462.000 and 468.000 to collect and drain the rain water form the slopes into chutes. The section of this drain is also equal to chute section. The chute and the horizontal drain was constructed over a bed of quarry rubbish of 12 cm thick.

For easy movement of inspection staff from top of bund to rear, toe drain masonry steps in R R 1:8 and plastering the top surface with CM 1:5 20 mm thick for 3 m wide were provided at LS points at 290, 510, 678 and 1010 m. The rise 20 cm and tread, 40 cm were adopted for these steps. At these points RCC slab culverts were also provided to cross the toe drain.

13.4.14 PARAPET AND ROAD ON TOP OF DAM

Parapet walls have been constructed on top of dam on either side with R R Masonry. The panel walls are of 40 cm wide. At every 5 m there is a pillar 50 cm x 60 cm and at every 15 m the pillar is bigger and the size is 70 cm x 60 cm. At every 45 m, one lap pillar of size 90 cm x 60 cm is constructed. Lamps are provided on the downstream wall only. The foundation for the walls and pillars alone is taken 60 cm below and the wall and the pillars are built over 15 cm thick quarry rubbish while the pillars are built over 15 cm thick concrete laid over 15 cm thick quarry rubbish. The downstream wall is 40 cm high while the upstream walls is 60 cm high. The pillars are 20 cm higher than these walls. 10 cm thick concrete coping is laid over walls and pillars.

The road on top of dam is 3.65 m wide. First a layer of 30 cm gritty soils mixed with stones were laid as soling and consolidated well. Over this soling one layer of water bound macadam road was been formed with 7.5 cm thick 50mm jeddy stones over 10 cms thick gravel and consolidated with power rollers. A bed of gritting soil was spread over this and was lightly rolled and left for a reason or two for natural compaction by the vehicles moving over the bund. It was proposed to black top the surface after two seasons. Another layer of water bound mecadam road was provided later.The surface dressing with tar and stone metal chips was done subsequently.

CHAPTER 14
DEPARTMENTAL SUPPLY OF EXPLOSIVES

14.1 BACKGROUND

It was envisaged in the later half of December, 1979, while submitting a biannual return on "Earth work projections, the volume of rock excavation involved in the implementation of this irrigation scheme would be in the order of 3,00,000m³ during its construction phase of 5 1/2 years from June 1979 to December, 1984. The break-up shown was as follows:

1979-80	50,000m³
1980-81	150,000m³
1981-82	100,000m³
Total	**300,000m³**

Two more schemes were going on not far away from Harur. One was at Ichambadi and another at Thumblahalli, both were under the administrative control of the Superintending Engineer, Project Circle, Krishnagiri. The consumption of explosives for these three schemes coming under the jurisdiction of one and the same circle was heavy.

Till January 1980, the contractors were obtaining their requirements of galatine etc. for blasting rocks from the open market. After the announcement of price increase for the supply of explosives outside the rate contract system, the availability of explosives in the district became erratic. The contractors were finding it increasingly difficult to procure the explosives from the private agents on their own initiatives from February, 1980 onwards. It was then became imperative on the part of the Department to under take the responsibility of procurement, storage and distribution of explosives themselves for rock blasting purposes and recover costs of supplies from the concerned Public Works Contractors to ensure orderly progress of excavation works so that the completion schedules of the schemes can be kept up. From them on every effort was taken to effect departmental supply of required explosive materials.

14.2 LICENCE TO DEAL IN EXPLOSIVES

Construction of magazine stores - Arrangements for lifting surplus stock of explosives from other divisions

Application forms for securing license from the Controller of Explosives were received by the Executive Engineer, Vaniar Reservoir Division on 29.02.80. This was sent by the Executive Engineer, P.A.P. Division, Pollachi.

The Assistant Executive Engineer, Vaniar Sub-division was asked to prepare and submit an estimate for a magazine store at Vaniar Dam site in March, 1980. The Deputy Controller of Explosives, Southern Circle, Madras was addressed to furnish type design for a 3.5 ton capacity magazine store through a

letter dated 12.03.80. Earlier in

February, 1980, the Superintending Engineer, Projects Circle, Krishnagiri addressed his counterpart at Pollachi for sparing gelatine. This was followed up by Executive Engineer V.R.P. who himself addressed other divisions for transfer of surplus explosive materials. The divisions contacted in this context were, Parambikulam Alair Project Division, Pollachi, Periar Improvement Division-II, Madurai, Sathanur right bank canal division at Thiruvannamalai etc. The Tamilnadu Electricity Board's civil construction division incharge of Kadambarai Pumping Scheme was also approached in this regard during September 1980. Detailed instructions for selection of site for magazine store were sent by the Superintending Engineer, Krishnagiri through memo No.584/D1/80 dated 07.04.80. The important point is that it should be separated from any habitated road by a distance of 129 meters minimum.

The procedure for obtaining licence to run a magazine were systematically followed beginning with the forwarding of application with site plan index map etc. to the controller of explosives in June 1980. Six copies of revised site plan showing the diverted road as per requirements were sent on 15.11.1980. Prior to this development, the Regional Inspector of Explosives, Madras and the Chief Inspector of Explosives, Nagpur were addressed (on 23.10.1980) for issue of a licence in the L. Form. They were also reminded by telegrams. Requests for issue of temporary licence at least were made in March 1981. As per explosive control regulations, the magazine itself had to be constructed after approval of the site plan by the Regional Inspector of Explosives, Madras after receipt of no objection certificate from the District Revenue Officer.

STAGES OF PROCESSING THE LICENCE APPLICATION

1. On receipt of application with enclosures of site plan etc. the Regional Inspector of Explosives forwards copies to District Authorities.

2. District Authorities publish notice of intention to build magazine at the given place.

3. If within 30 days no valid objection is received NOC will be issued.

4. On receipt of NOC the applicant will be advised to proceed with the construction of magazine by Chief Inspector who also marks copies and forward license in Form-L to Regional Inspector. Copies of this licence with site plan are also forwarded to District Authorities.

5. On completion of the building the Regional Inspector is to be informed who after inspection endorses the licence. The magazine then will be used for storing explosives.

14.4 The magazine building strictly conforming to specifications and procedures above was put up at the approved site in the north eastern corner of the campus and the permission was obtained after the magazine store was inspected by the District Fire Officer and the Regional Inspector of Explosives who en-

dorsed the license which then became valid. It was nearly two years since the first attempt was made for the magazine store to function usefully.

14.5 The requirements of gelatine etc. during the years 1980 and 1981 were managed by inducing the contractors to procure them privately and also by arranging with the other PWD Divisions who already held valid licenses to store and distribute the explosives. In fact a letter was sent on 23.12.1980 to the Executive Engineer, PWD SRBC Division, Thiruvannamalai to procure and supply the following materials for use in VRP during 1/81 to 10/81

i)	Gelatine	-	10 (ten) tonnes
ii)	Detonators	-	50,000numbers
iii)	Fuse wire	-	1,00,000 metres

He was also asked to spare the explosive van to transport these magazines to Vaniar Dam site.

The supplies were not however, drawn since the storing facilities at Vaniar site were not available till late 1981.

14.6 PROCUREMENT OF SMALL QUANTITIES OF EXPLOSIVES BY CONTRACTORS

There are provisions in the explosive regulations act under which small quantities of explosives can be obtained without going through the rigours of the licensing procedures stated above. If the quantity does not exceed 200 lbs the applicant can obtain NOC direct from the district authorities. However, Form C is to be filled and sent to Regional Inspector of Explosives. Upto 5 kg of Nitrogenous compounds, the local authorities are empowered to issue a `J' form license along with 200 detonators and reasonable quantities of safety fuse.

The contractors were advised to take advantage of these provisions and obtain explosives as and when required which they did to keep the tempo of progress.

In the case of Vaniar Head Works, it is seen from the BFPR remarks that the progress was slowed down only during the months of July and August 1980 due to shortage of explosives and during other periods the excavation works were making steady progress. Barring the occasions of diesel shortage, power cuts and break down of heavy earth moving equipment over which the executive staff had little control, the blasting works were done as per agreed programme.

CHAPTER 15
ARTICLES OF INTEREST - VENERATION FOUND DURING EXCAVATION

15.1 As per preliminary specifications and conditions of contract any object of archaeological importance or religious interest found during excavations shall be the property of the Government. They shall be handed over to the specified authorities for safe custody.

15.2 In the water spread area of Vaniar Dam when excavation for the diversion channel was in progress a stone piece about a foot high vaguely resembling an idol was recovered. Since the shape of the object or its features were not so perfect as to readily recognise it as an article of importance or veneration, no one among the technicians took a serious note of it. A couple of days later one of the new members of the machinery unit narrated a premonition that in his dream he heard a voice as if coming from a Goddess that the object they had found and recovered from the excavations was not an ordinary one. It has divine qualities and in fact the reigning Goddess of the area, Muthumariamman manifests in the same; therefore the holy article has to be treated with devotion and given all rites and respects worthy of an Idol of the Lord Almighty.

15.3 The news spread and every one of the early inhabitants of the campus started looking at the "Crude" idol with respect and veneration "Bakthi". Soon the appeal was made to donate money for a building to install the idol and start daily rituals - poojas - though in a humble way to start with. A temporary building with asbestos roofing was put up below an Arasu tree in the campus area and the idol consecrated in the small sanctum sanatorium inside. People of the colony started worshipping the Deity. The collections swelled and in the course of time a group of devortees got a fine stone statue, about three feet high neatly sculptured to represent the resigning Deity of the place Goddess Arulmigu Muthumariamman and installed the same behind the original idol recovered from the reservoir area and continued the poojas as before.

15.4 Close by this place of worship in the campus sprang another temple of more permanent in nature a couple of years later. It is a small regular temple and built purely out of donations of staff of the Division, Sub-Divisions and sections engaged in the construction of the Dam appurtenant works and the inhabitants of the nearby Vami Hill. This temple has a small gopuram over the sanctum sanatorium with a Kalasam on top. The Diety installed in this second temple is Goddess Arulmigu Vaniamman associating with the name of the dam. Thus the colony has had a place of worship almost since its inception and its inhabitants, past and present has had the satisfaction and inner peace that they conform to the common saying "No one need to reside in a village or town which has no place of worship - i.e. "Koil Illa Ooril Kudiyirukka Vendam".

This colony is now one of the many places in Dharmapuri District where the refugees from Srilanka are accommodated.

The stages of progress and slippages in the completion of this major component (i.e. Earth Dam) were as follows:

February, 1980 : Negotiations with TAPWEC - programmes for commencement conditions etc. were discussed. An advance of Rs.10 lakhs was paid to this Government undertaking. Tenders received from piece works contractors for earth works and filling incut-off trench were found to be 5 percent excess over the then prevailing schedule of rates.

May to June, 1980 : Cut-off trench works between L.S. 300 and L.S. 600 and from L.s. 1100 to 1290 were being expeditiously done.

July to August 1980 : Above works continued in full swing. Lands for the reach between 730 m and 1040 m were handed over and tenders for cut-off trench works here were called for.

September to December, 1980 : Nine percent completion of dam components works was achieved.

February to March, 1981 : Excavations for cut-off trench in reach 1040 m to 1120 m were over. Tenders for filling with impervious soil were called for. Superintending Engineer instructed to take up the cut-off trench works in river course portion immediately.

July to August, 1981 : Fifty percent of the cut-off trench works were over. About 6,000m^3 short fall was attributed to heavy rains. Some contracts in hillock removal were cancelled. Embankment formation by machineries had commenced. Units go out of order often. Expected rate of progress could not be achieved.

September to October 1981 : New agencies had come in for hillock removal; of the 47000m^3 involved, 27000m^3 had been removed. Programme was furnished by local officers that it is possible to do only 3.82 lakhs m^3 by TAPWEC till September 1982. In order to have the second diversion functioning the total volume of earth to the dumped is 4.48 lakhsm^3. Hence to keep up the programme, it was proposed to form earth dam between L.S. 640 m to 1000 m using contractor's lorries for conveyance with power roller consolidation. CE's approval was sought for.

November, 1981 : Cut-off trench filling works were almost completed.

Upto February, 1982 : Labour shortage due to harvesting season contractors in hillock removal had to do works in turns because of shortage and repair of compressors. Actions for acquisitions of new ones were under way. In the reach between 400 to 620 m cut-

off trench filling and the embankment formation works by machineries were completed. Level reached here is 460.0 m. Above this elevation earth cut out from the sides are to be dumped and this has to be done manually. In the reach between 800 and 950 m, cut-off trench filling works were in progress, water springs were encountered. Tampers pumps and compressors from other divisions were diverted to work in these places.

Total quantity of filling involved in cut-off trenches	-	73,000M³
Target till 2/82	-	56,000M³
Quantity achieved	-	29,200M³

On the right side of river course, cut-off trench filling and laying of filter medium were in progress. This part of work had to be speeded up so that machineries for embankment formation could move in April, 1982.

Earth work involved in embankment	-	12,90,000M³
Target upto 2/82	-	87,000M³ (32%)
Actual achievement	-	60,000M³ (14.2%)

FILTER AND ROCK TOE WORKS

These were nearing completion in the reach between 400 m and 600 m and were in progress in the section from 820 m to 1030 m.

Total Quantity (as on 2/82)	-	65,000M³
Target till 2/82	-	21,000M³ (32%)
Completed upto 2/82	-	9,300M³ (14.2%)

Executive Engineer was asked to take penal action against the defaulting contractors and step up progress.

March-April, 1982 : Diesel shortage was felt; Machineries did not work fully.

May-June 1982 : Chief Engineer directed both S.E. and E.E. to bestow personal attention to speed up all works and especially the progress on earth dam which is critical.

July to August, 1982 : All cut-off trench works were completed. A judicious mix of excavation works in embankment formation between TAPWEC through machineries and manually with lorries and departmental road roller by private contractors were settled. This is due to frequent breakdown of machineries and sickness and private contractors clamouring for works since they did not want to keep idle due to suspension of works for want of diesel and cement. Portions were fixed so that there was no overlap or confusion.

No more hillock removal work was found necessary since the left out portion at this stage fell entirely with in the downstream side shell zone of the earth dam. Modifications of filters and rock toe in this section were ordered.

Achievements

Embankment	Total Quantity	-	12.13 lakhsM^3 (slight revision due to above modifications)
	Target till 8/82	-	2.42 " (20%)
	Achieved	-	2.14 " (18%)
Rock Toe and Filters	Total	-	56,200M^3 (Revision due to the above reason)
	Target till 8/82	-	42750M^3 (76%)
	Achieved	-	31750M^3 (56%)

October 1982 to February 1983 : Power cut was acute during this period cement from factories could not be lifted. Masonry works came to a standstill. To avoid hardship to labourers, earth works in embankment formation were entrusted to contractors' instead of TAPWEC in certain sections where machinery would not work conveniently - such as flank ends where height is small, either sides of masonry components.

January to February, 1983 : A case of contractor's failure due to lapse of time - cost and time over-run. The work of forming zoned filter rock toe and toe drains in V.R.P. reach from L.S. 640 m to 820 m was entrusted to one Thiru. V.Rajendran for an agreement value of Rs.4,31,710/- in Agreement No.43 Se/SPC.81 - 82. The work in this stretch between 640 to 750 m could not be done as the hillock present in this place could not be removed to the required level. Hence the contractor executed the portion between 750 m and 820 m only. In the meantime, the contractor fell sick and desired to finalise his accounts. The department had to concede his request as the work site could not be given to him within the prescribed period. The value of left over work was Rs. 3.3 lakhs.

Also the portion between 620 m and 640 m where the 2nd diversion was originally proposed had also to be taken up for earth dam by that time. As such the filter work from L.S. 620 m to 750 m had to be taken up to keep up the target. The total value was estimated to be 4.0 lakhs. As there was no time to advertise in papers, it was proposed to split up the work into 4 (four) reaches and call for short notice tenders at Division level and decide the agency. As the ban for splitting up works had been imposed by the Government by then the Executive Engineer addressed the S.E. and Chief Engineer to obtain Government orders ratifying his action. It was also pointed out that the idle labour and plants at the disposal of the contractors at that time could be usefully inducted into these very urgent works and care would be taken to settle the agencies at rates not exceeding the original contract rates to avoid loss to Government. The action was fortunately ratified by the Government later.

April, 1983 : In the reach 600 to 1,000 m, Filters and revetment works were in progress.

May, 1983 : In reach 160 m to 290 m toe drain and embankment works were in progress. The level of 468.0 m was reached in sections 620 m to 750 m and from 160 m to 290 m. The level up to which machinery can work had been fixed as 469 m.

October, 1983 : Revetment works were in progress. Elevation 465.50.

November and December, 1983 : Second stage river diversion works through left side sluice and left out works near the left tower head sluice were taken up by employing heavy machineries.

January, 1984 : Filter formation and revetment works in the reach 600 m to 1000 m were in advanced stage of progress.

July to August, 1984 : Heavy machineries closed the river bed portion completely (on 10.08.84) bund level reached was 472.0 m. The top 3 meters was achieved by dumping the earth cut from slopes manually.

ANNEXURE

VANIAR RESERVOIR SCHEME

EARTH DAM ZONED SECTION **DESIGN OF FILTERS AT LS.1265**

TYPE X

G.L. = 451.00 m B = 44.B

h = 20 m, `M' = 20 m

c = h/3 = 6.67 m

d = B - .7m = 44.3 - .7 x 20

= 30.3m

ℓ_1 = 29.375 m

1) SEEPAGE THROUGH EMBANKMENT

Average co-eff. of permiability as per EE. SM & R. Lr.No. Soil/TR/17/77, Dt.30.11.79 and Lr.No. 211/80, dt.26.06.81.

$$= \frac{10^{-6}(12q+2.6+12.7+17.0+3.55)}{5} = 32.97 \times 10^{-6} \text{ cm/sec.}$$

I a) q = $K\left[\sqrt{h^2+d^2} - d\right]$

= $32.97 \times 10^{-6}\left[\sqrt{(20,00)^2 + (3030)^2} - 3030\right]$

= 19800×10^{-6} cm³/sec

I b) q = $\frac{4\,Kh^2}{9l}$ [vide eqn. 14 in page 675 of eng. for dams by creager justin vol.III]

Where ℓ = $(1.3h+2z-\ell/2)\cot\alpha+\omega$

Where Z = diff. in - elevation between top at IPZ and MWL)
W - is top width of IPZ = 2.5m

Z = 471.9 - 471.0 = 0.9 m

ℓ = $[1.3(20)+2(0.9)- \frac{6.67}{2}]$ at 45⁰+.2.5

= (2.6+1.8 - 3.335)+2.5

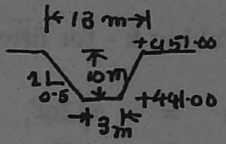
= 26.965m

q = $\frac{4(32.97\times10^{-6})\,20^2\times100^2}{9\,(26.965)\times100} = 21737\times10^{-6}$ cm³/sec.

The higher value is taken as seepage through the embankment = 0.021737 cm^3/sec/cm length of dam.

2) **SEEPAGE THROUGH FOUNDATION:**

A) **SEEPAGE THROUGH PARTIAL CUT OFF:**



q = ki A = K h/l.A

when, hydraulic head h = 20 metres

h/2 = 10 m

ℓ = seepage path (ave) = $\frac{13+3}{2}$ = 8.0m

Average flow A = 1000 x 1 = 1000 c^2

q = 32.97 x 10^{-6} x $\frac{20}{8}$ x 1000 = 82425 x 10^{-6} Cm^3/sec/cm.

= 0.082425 cm^3/sec/cm.

b) **Seepage underneath partial cut off:**

As the bed rock is well bellow the bottom of cut off a height = the depth of cut off is considered for calculation of seepage below cut off.

Insitu co-eff of permeability at L.S. 1265m
as per EE/SM R Lr.No.Soi/211/dt.16.07.80 q = k h/l1 A = 44264 x 10^{-6} cm/sec.

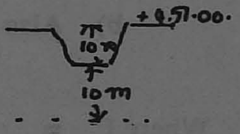
EE/SM&R. LR. NO. SOIL 211/DT-16-7-86

Q = K h/l' A.

where ℓ_1 = the seepage length from U/s toe of cut off D/S toe of slope.

h = 20m; A = 1000 x 1 = 1000 cm^2

ℓ_1 = ℓ_1+B = 29.375 + 44.3 = 73.675 M.



Q = 442.46 x 10^{-6} x $\frac{20}{73.675}$ x 1000

= 120111.0x10^{-6} Cm^3/sec/cm

= o.1201 cm^3/sec/cm

DESIGN OF FILTERS:

The filter has to be designed for twice the seepage flow through the dam plus seepage through foundation:

q = .0217
.0217
.0824
<u>.1202</u>
.2460 cm^3/sec/cm.

$q = k.\frac{h}{\ell}.A = \frac{K h^2}{2\ell_1}$ when h is the thickness of filter

length of filter proposed l1 = 29.375 m

Taking k - for filter material as 750 x 10^{-4} cm/sec

$$h = \sqrt{\frac{2q\ell_1}{K}}$$

$$h = \sqrt{\frac{2x0.246 \times 2937.5}{750x10^{-4}}} = 139 \text{ cm or say } 150 \text{ cm}$$

DESIGN OF FILTER AT L.S. 1165 M: (TYPE X)

G.L. El = 449.00 m

h = 22m = m

e = h/3 = 7.33m

B = 48.30 m

d = 8-0.7m = 48.3-0.7 x 22 = 32.90m

ℓ_1 = 31.175m

1. Seepage through embankment :

a) $q = K(\sqrt{h^2+d^2} - d)$

$= 32.97 \times 10^{-6} (\sqrt{2000^2 + 3290} - 3290)$

$= 0.0185$ cm³/sec/cm.

b) Also $q = \frac{4 kh^2}{9\ell}$

Where $l = (1.3h + 2z + \frac{\ell}{2}) \cot \alpha + \omega$

$= (1.3x20+2x0.0+\frac{7.33}{2}) \cot 450^0 + 2.5$

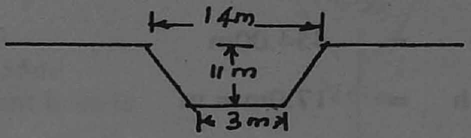
$= 31.465$ m

$q = \frac{4x32.97 \times 10^{-6} \times 2000^2}{9 \times 3146.5}$

$= 0.0186.$ c³/sec/cm

2. Seepage through foundation:

a) Seepage through partial cut-off:



$$q = K \frac{h}{\ell} A$$

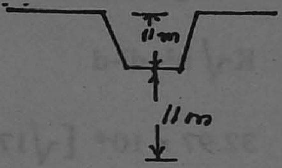
Average seepage path $\ell = \frac{14+3}{2} = 8.5m$

$A = 110\ Cm^2$

$$q = 32.97 \times 10^{-6} \times \frac{22}{8.5} \times 1100$$

$$= 0.0939\ cm^3/sec/cm\ length$$

b) Seepage underneath partial cut off:



Insitue - K at LS 1165 m

$= 667.87 \times 10^{-6}$ cm/sec.

h = 22 m, $A = 1100\ cm^2$

$\ell_1 = \ell_1 + \beta = 31.175+48.3$

$= 79.475M.$

$$q = K \frac{h}{\ell_1} -A$$

$$= 667.87 \times 10^{-6} \times \frac{22}{79.475} \times 1100$$

$$= 0.0428\ c^3/sec/cm$$

DESIGN OF FILTER:

Twice 'q' through embakment 2x .0186 = $0.0372\ cm^3/sec/cm$

Seepage through cut off = 0.0939

Sepage underneath coeff. = 0.0428 "

$0.1739\ cm^3/sec/cm.$

Taking K - value for the filter material as 750×10^{-4} cm/sec. the thrickness of filter

lagor $h = \sqrt{\frac{2q\ell_1}{k}}$

where l1 = 31.175m

$$h = \sqrt{\frac{2x0.1739 \times 3117.5}{750 \times 10^{-4}}}$$

= 120.2cm or say 130 cm

III. DESIGN OF FILTER AT L.S. 1295M:

G.L.El = 454.00m

h = 17.0m = m

e = h/3 = 5.67m

B = 36.50 m

d = B-0.7m = 36.5 - 0.7x17 = 24.60m

ℓ_1 = 26.075m

1) Seepage through embankments:

a) $q = K\sqrt{h^2+d^2}-d$

$= 32.97 \times 10^{-6} \left[\sqrt{1700^2 - 2460^2} - 2460\right]$

$= 0.0175\ c^3/sec/cm$

b) Also $q = \dfrac{4\ kh^2}{9\ell}$ where.

$\ell = (1.3x17+2x0.9+\dfrac{5.67}{2}) \times 1.0+2.5$

$= 29.235\ m$

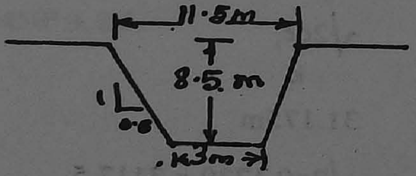
$q = \dfrac{4x32.97x10^{-6}x1700^2}{9x2923.5}$

$= 0.0145\ cm^3/sec/cm$

2) SEEPAGE THROUGH FOUNDATION:

a) Seepage through partial cut off:

Average seepage path = $\dfrac{11.5+3.0}{2}$



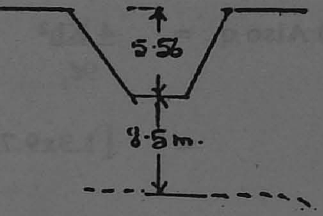
ℓ = 7.25m

A = 850 cm^2

$q = k\ \dfrac{h}{\ell}\ A$

$q = 32.97 \times \dfrac{1700}{7.25} \times 850 \times 10^{-6}$

$= 0.0657\ cm^3/sec/cm$



b) Seepage underneath partial cut off:

As field permeability test at this L.S. was conducted at a depth of only 5.56m from G.L. the K value for the adjasent bore is

k = 667.87 cm/sec has been adopted.

h = 17m, A = 850 cm²

ℓ_1 = 11+B = 26.075 + 36.5 = 62.575 m

q = $k = \frac{h}{\ell_1} A$

= $667.87 \times 10\text{-}6 \times \frac{17}{62.575} \times 850$

= 0.1542 cm³/sec/cm

Design of filters:

2 x seepage through embankment = 2x0.0175

= .350 cm³/sec/cm

" cut off = .0657 "

below " = <u>.01542 "</u>

0.2549cm³/sec/cm.

Taking k - for filter material as 750 x 10^{-4} cm/sec/

h = $\sqrt{\frac{2q\ell_1}{K}}$ = $\sqrt{\frac{2x0.2549x2607.5}{750 \times 10^{-4}}}$

= 133 cm or 140 cm

DESIGN OF FILTER AT L.S. 520 M:

G.L. El.461.30m ; h = 9.70 m; e = h/3 = 3.23m = m

B = 21.90 m; d = B-0.7m = 15.11 m

ℓ_1 = 14.795 m

1) Seepage through embankment:

a) q = $k[\sqrt{h^2+d^2}-d]$

= $32.97 \times 10^{-6} [\sqrt{970^2 + 1511^2} - 1511]$

= 0.009382 cm³/sec/cm

b) Also q $= \dfrac{4\,Kh^2}{9\ell_1}$ where $l = (1.3\ h + 2\ Z + \ell/2)\cot \alpha + \omega$

$= \left[1.3x9.7x2x0.9+\dfrac{3.23}{2}\right]x1+2.5$

= 18.525m

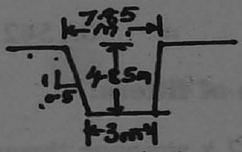
q $= \dfrac{4x32.97\ x\ 10^{-6}\ x\ 970^2}{9x18525}$

= 0.007443 cm³/sec/cm.

e) Seepage through foundation:

a) thro'cut off:

Ave. seepage length $\ell = \dfrac{7.85+3.0}{2} = 5.425m$



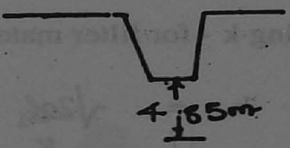
q $= k\dfrac{h}{\ell}.A = 32.97x10^{-6}\ x\ \dfrac{9.7}{5.425}\ x\ 485$

= 0.02859 c³/sec/cm

b) Underneath cut off:

$\ell_1 = \ell_1+\beta = 14.795+21.9 = 36.695m$

q $= k.\dfrac{h}{\ell}.A = 496.57x10^{-6}\ x\ \dfrac{9.7}{36.695}\ x\ 485$



= 0.06 366 cm³sec/cm

DESIGN OFFILTER:

Design seepage q = .009382
.009382
.02859
.06366

q = 0.11101 cm³/sec/cm

Adopting standard k - value

for, the filter material as
750 x 10-4 cm³/sec

Thickness of filter $h = \sqrt{\dfrac{2q\ell_1}{k}} = \sqrt{\dfrac{2x.11101x1479.5}{750x10^{-4}}}$

=66.2 or say 70 cm

V. Design of filter at L.S. 400 m:

G.L.El.465.00m; h = m = 6.0 m; l = h/3 = 2.0m

B = 16.3m; d = B-0.7m = 12.100

l1 = 11.375m

i) **Seepage through embankment:**

a) $q = k\sqrt{h^2+d^2} - d$

$= 32.97 \times 10^{-6} \sqrt{600^2 + 1210^2} - 1210$

$= .0046\ cm^3/sec/cm$

b) Also $q = \frac{4\,Kh^2}{9\ell}$; where $\ell = (1.3\ h + 2z+\frac{\ell}{2})\ \cot \alpha+\omega$

$= [1.3x6+2x0.9+2/2]\ 1+2.5$

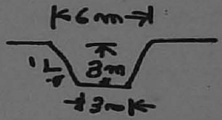
$= 13.10m$

$q = \frac{4x32.97 \times 10^{-6} x\ 600^2}{9x1310} = 0.000396\ cm^3/sec/cm$

2) **Seepage through foundation:**

a) **Through partial cut off:**

l - seepage length = $\frac{6+3}{2}$ = 4.5m



$q = K\frac{h}{\ell} - A$

$= 32.97 \times 10^{-6} \times \frac{6}{4.5} \times 300 = 0.01319\ cm^3/sec/cm$

B) **UNDERNEATH PARTIAL CUT OFF**

$\ell_1 = \ell_1+\beta = 11.375 + 16.3 = 27.675\ m$

$q = K\frac{h}{\ell_1}.A = 361.4 \times 10^{-6} \times \frac{6}{27.675} \times 300$

$= 0.02351\ cm^3/sec/cm$

Design of filter:

Design seepage: .0046
.0046
.01319
.02351

q = 0.04590 cm³/sec/cm

Adopting standard K - value
for the filter material = 750 x 10^{-4} cm/sec.

Thickness of filter h $= \sqrt{\dfrac{2q\ell_1}{K}}$

$= \sqrt{\dfrac{2x.0459x1137.5}{750x10^{-4}}}$

= 37.3 or say 40 cm

Sd/-
for Superintending Engineer,
PWD, Designs Circle, Chepauk, Chennai-5.

PART II
ANNEXURE 2

Vaniar Reservoir Scheme : Earth dam - Earthquake analysis - Downstream slope - Trial No.4 values adopted

NORMAL FORCES

S.No.		Material	Area in	(Maist & saturated) unit wt. of material in kg/^{3}	alt. of slice W	Cos θ	W1cos θ	Remarks
1.	SPZ	moist	21.12	2307	48.7238	0.9781	47.6567	
2.	SPZ	moist	44.60	2307	102.8922	0.9945	102.3263	
3.	SPZ	moist	63.60	2307	146.7252	1.0000	146.7252	
4.	SPZ	moist	78.24	2307	180.4997	0.9945	179.5070	
5.	SPZ	moist	87.60	2307	202.0932	0.9763	197.3036	
6.	SPZ	moist	95.80	2307	221.0106	0.9483	209.5844	
7a.	SPZ	moist	85.00	2307	196.0950	0.9067	177.7993	
8a.	SPZ	moist	66.60	2307	153.6462	0.8434	129.5852	
9a.	SPZ	moist	45.50	2307	104.9685	0.7660	80.4059	
10a.	SPZ	moist	26.40	2307	60.9048	0.6626	40.3555	
11a.	SPZ	moist	9.36	2307	21.5935	0.4924	10.6326	
17b.	IPZ	Saturated	8.00	2067	16.5360	0.9063	14.9866	
18b.	IPZ	Saturated	25.80	2067	53.3286	0.8434	44.9773	
19c	IPZ	Saturated	34.80	2067	71.9316	0.7660	55.0096	
10c.	IPZ	Saturated	25.80	2067	53.3286	0.6626	35.3355	
11c.	IPZ	Saturated	4.0	2067	8.2680	0.4924	4.0712	
19b.	IPZ	moist	1.30	1924	2.5012	0.7660	1.9159	
10b.	IPZ	moist	10.20	1924	19.6248	0.6626	13.0034	
1b.	IPZ	moist	14.52	1924	27.9365	0.4924	13.7759	
						εW1 Cos θ	1505.0271	

VANIAR RESERVOIR SCHEME - EARTHQUAKE ANALYSIS - DOWN STREAM SLOPE : TRIAL NO.4, VALUES ADOPTED.

TANGENTIAL FORCES

S.No.		Material	Unit wt	Weight of slice	Sin θ	W2Sin θ T	Tan φ	N Tan φ Ti	Remakrs
1.	SPZ	moist	21.12	48.7238	0.2079	(-)10.1297	0.6249	(-)6.3300	
2.	SPZ	moist	44.60	102.8922	0.1045	(-)10.7522	0.6249	(-)6.7190	
3.	SPZ	moist	63.60	146.7252	0.0000	0.0000	0.6249	(-)0.0000	
4.	SPZ	moist	78.24	180.4997	0.1045	18.8622	0.6249	11.7870	
5.	SPZ	moist	87.60	202.0932	0.2164	43.7330	0.6249	27.3288	
6.	SPZ	moist	95.80	221.0106	0.3173	70.1267	0.6249	43.8222	
7a.	SPZ	moist	85.00	196.0950	0.4226	82.8697	0.6249	51.7853	
8a	SPZ	moist	66.60	153.6462	0.5373	82.5541	0.6249	51.5881	
9a.	SPZ	moist	45.50	104.9685	0.6428	67.4738	0.6249	42.1644	
10a.	SPZ	moist	26.40	60.9048	0.7490	45.6177	0.6249	28.5065	
11a.	SPZ	moist	9.36	21.5935	0.8704	18.7950	0.6249	11.7450	
7b.	IPZ	saturated	8.00	16.5360	0.4226	6.9881	0.3839	2.6827	
8b.	IPZ	saturated	25.80	53.3286	0.5373	28.6535	0.3839	11.0001	
9c.	IPZ	saturated	34.80	71.9316	0.6428	46.2376	0.3839	17.7506	
10c.	IPZ	saturated	25.80	53.3286	0.7490	39.9431	0.3839	15.3342	
11c.	IPZ	saturated	4.00	8.2680	0.8704	7.1965	0.3839	2.7627	
9b.	IPZ	moist	1.30	2.5012	0.6428	1.6078	0.3839	0.6172	
10b.	IPZ	moist	10.20	19.6248	0.7490	14.6990	0.3839	5.6429	
11b.	IPZ	moist	14.52	27.9365	0.8704	24.3159	0.3839	9.3349	
						εT = 578.7918	εTi =	320.8036	

VANIAR RESERVOIR SCHEME

Earthquake analysis - D/S slope - Trial 4 values adopted.

αh = BI $\alpha 0$ = 1x2x0.02 = 0.04

Where B = coefficient depending upon soil foundation system

= 1 for dams (Table 3 IS 1893/75)

I = coefficient depending upon the importance of the structure.

= 2 for dams (Table 4 IS 1893/75)

$\alpha 0$ = Basic horizontal seismic coefficient as given in Table 2 of IS 1893/75 = 0.02

$$\alpha Y = \left(4.0 - 2.4 \frac{Y}{H}\right) \times h.$$

Where Y = depth at which uniform seismic coeff. is required

H = Total height of dam.

αY = Equivalent uniform seismic at depth Y.

Now as weare concidering at the bottom of the dam

$$\alpha H = (4.0 - 2.4)\ \alpha h$$

$$= 1.6 \times 0.04 = 0.064$$

$$F.S. = \frac{\varepsilon C + \varepsilon N \text{ Tan} + \varepsilon \text{ Ti} \times \alpha h}{\varepsilon T + \varepsilon W1 \text{ Cos.}\phi\ \alpha H}$$

$$= \frac{168.4126 + 771.6374 - 320.8036 \times 0.064}{578.7918 + 1505.0271 \times 0.064}$$

$$= \frac{168.4126 + 777.6374 - 20.5358}{578.7918 + 96.3217}$$

$$= \frac{925.5142}{675.1135} = 1.37 > 1.0 \text{ Hence safe}$$

Sd/-
for Superintending Engineer,
Designs Circle, PWD,
Chepauk, Madras - 5.

ANNEXURE

PUBLIC WORKS DEPARTMENT

From	To
Natarajan, B.E. (Hons) Executive Engineer, PWD Vaniar Reservoir Project Dn.I Harur - 636 903 Dharmapuri (District)	The Superintending Engineer, PWD Special Project Circle Krishnagiri.

LR.NO.44SE/F1/D.0.5/DATED 27.01.83

Sir,

Sub: Vaniyar Reservoir Project - Formation of filter, rock toe and toe drain between 620 to 750 m - Splitting up - permission requested - regarding.

REf: Arrising.

The work of "Forming zoned filter, rock toe and toe drain for Vaniar Project from LS 640 to LS 820 was entrusted to one Thiru N.Rajendran for an agreement value of Rs.4,31,710/- in Agreement No.43SE/SPC/81-82. In this the stretch between 640 to 750 the work could not be done as the hillock present in this place was not removed to the required level. Hence the contractor executed the portion from 750 to 820 and the work is nearing completion.

In the mean while the contractor fell sick and hence has represented that he is not in a position to do the work from 640 to 750 and desired to finalise his accounts. The value of work left over is about Rs.3.3 lakhs.

Also the portion from 620 to 640 left over originally for second diversion is proposed to be taken up now. As such the filter from 620 to 750 is to be executed immediately to keep up with the programme of formation of Earthern dam in this reach. The value of this work is about Rs.4.00 lakhs. As there is pno time to notify in papers and settle tenders advertising in a papers it is proposed to be split up into 4 reaches and call for to short term tenders at Division level and decide the agency and complete the work early.

Besides for want of cement, the contractors executed masonry works are without work with their over head idle can be inducted usefully in this work which requires.

Care will be taken to settle the agency at rates not exceeding the original tender rates to avoid loss to Government.

As splitting up of work is banned now. I request to orders of conpentant authority for splitting up of work special case may be obtained and communicated.

Sd/-
Executive Engineer
V.R.P. Division.

ANNEXURE

Copy of :

GOVERNMENT OF TAMIL NADU

ABSTRACT

Irrigation - Dharmapuri District - Vaniar Reservoir Project - Splitting up of works - proposal of Chief Engineer (Irrigation) - Accepted.

PUBLIC WORKS DEPARTMENT

G.O.Ms.No.807 Dated 09.04.1983

Read again:

G.O.Ms.No.284, Public Works, dated 20.02.79.
G.O.Ms.No.1067, Public Works, dated 29.05.82.

Read also:

From the Chief Engineer (Irrigation)
D.O. Letter No.P4/15737/79-159, dated 31.01.83.

ORDER:

In the circumstance explained by the Chief Engineer (Irrigation), the Government, as a special case, approve his proposal to split up the work of raising filters and rock-too in the rear of the earth dam of Vaniar Reservoir Project in relaxations of the orders issued in G.O.Ms.No.1067 Public Works, dated 29.05.82.

2. The Government also ratify the action of the Chief Engineer (Irrigation) in having instructed the Superintending Engineer Projects Circle, Krishnagiri, to split up the works referred to in para I above into convenient parts and entrusted the work to more than one contractor in anticpation of approval of the Government.

3. This order issues with the concurrence of Finance Department vide its U.O.No.18179/P.W./83-1, dated 25.02.83.

(By Order of the Governor)

K. MADHAVA SARMA
Commissioner & Secretary to Government

To
The Chief Engineer (Irrigation),
Madras-5.

/True copy/ Forwarded by order /

ANNXURE

TYPICAL SECTIONS OF EARTH DAM OF VANIAR DAM

Type	Height of earth Dam	Depth of Storage	Drainage arrangements	Parapet wall or Kerb Wall	Revetment	Re marks
I.	0 to 3 M	0 to 0.9M	No filter	Kerb wall 0.2M thick taken 0.45M below TBL & 0.2M above TBL	Revetment 45cm thick over 23 cm thick quarry rubbish or gravel backing.	
II.	3 to 5M	0.9 to 2.9M	Only toe filter of 0.9 M thickness with 0.3 M thick sand layer:	- do -	- do -	
III.	5 to 6M	2.9 to 3.9M	Only toe filter of 0.9M thick with horizontal sand filter 0.3M thick.	- do -	- do -	
IV.	6 to 7M	3.9 to 4.9M	Toe filter of 0.9M thick with horizontal zoned filter of 0.5m thick.	- do -	- do -	
V.	7 to 8M	4.9 to 5.9M	Toe filter of 0.9M thick with horizontal zoned filter of 0.7M thick.	-do-	-do-	
VI.	8 to 9M	5.9 to 6.9M	Toe filter of 0.9M thick with horizontal zoned filter of 0.9M thick.	Parapet wall of 45 cm thick as noted below.	-do-	
VII.	9 to 15M	6.9 to 12.9M	Horizontal zoned filter of 0.9M thick and rock toe of 20% of height of dam.	Parapet wall of 45cm thick taken to 0.6M in front and 0.45M in rear above TBL and 0.6M below TBL on both sides.		
VIII.	15 to 21M	12.9 to 18.9M	Horizontal zoned filter of 1.2M thick with rock toe of 20% Ht. of dam.	-do-	-do-	
IX.	21 to 32M	18.9 to 29.9M	-do-	-do-	-do-	

CHAPTER 16
COMPONENTS OF THE DAM

16.1 FOREWORD

The following items constituted the components of the Vaniar Dam :

i) Surplus Regulator
ii) Surplus Course
iii) Main Canal (Tower Head) Sluices - 2 Nos.
iv) Saddle Escape

The first two are the high cost items after the earth dam. This chapter deals with the various aspects which are considered during the formulation and design stages of these components, specifications adopted for constructing them, and the modifications made during their progress and steps taken up to reduce the costs involved.

16.2 The planning and implementation of the works related to these items especially items (i) and (iii) represent a critical stage in the construction programme of the project. A brief description and necessity of these components are therefore given in the foregoing paragraphs and also under each subhead.

16.3 The dam site chosen after two other alternative alignments is adjudged to be satisfactory. The river flows through a deeply carved valley close to the mountain range on the right and then turns left. As per the investigation report there is no rock available even after 20 m depth in the river bed or any other place along the alignment of the dam. The proximity of the mountains indicated fast silting up and also quick filling of the reservoir after incidence of rains in the hills.

16.4 Therefore appropriate design concepts were evolved and drawings prepared for estimation and tender call purposes. As observed earlier, this was not preceded by comprehensive and detailed site explorations. When foundations were opened reasonably harder strata were found to exist at levels higher than previously determined and shown in the drawings. Frequent inspections of the Superintending Engineer Project Circle and timely site visits of the Chief Engineer Irrigation went a long way in taking advantage of these ground realities to modify the design and construction details with a view to achieve economy in the project cost. Instances of such nature are highlighted in the relevant paragraphs under this chapter.

16.5 TEMPORARY (REFERENCE) BENCH MARKS

As was mentioned before a permanent Bench Mark (BM) was established at site and its reduced level (R.L. or Elevation - E.L) in terms of Mean Sea Level (M.S.L) was determined by running check levels from Bommidi Railway Station. The various components of the reservoir were widely dispersed. Fixing levels for them at various construction stages by running fly levels from this permanent BM. every time is a time consuming and difficult

task. This repetitive work can be avoided if reference bench marks - temporary BMs are fixed at a number of places along the earth dam and surplus course and at the sites of surplus regulator and the two tower head sluice.

Accordingly temporary BMs in cut stone of size 15 cm x 15 cm and 60 cm long with its top square face neatly chisel dressed to a horizontal plane was erected at the required sites and was built around with concrete base and masonry in lean cement mortar to the full height so that it can stand undisturbed till the component works are completed. The base concrete on a firm base was of size 75 cm x 75 cm x 15 cm (thick and is in cement concrete of mix 1:8:16 proportion. The R.R. masonry surrounding the cut stone was of size 60 cm x 60 cm x 45 cm with its top plastered flush with the cut stone top face. These temporary BMs were provided at convenient spots little away from the margins of the work site where they would not get disturbed or interfere with the progress of works and were dismantled after their purpose was served.

CHAPTER 17
SPECIFICATIONS

The following specifications were adopted for the construction of all the components of this dam.

17.1 WATER

The water used in concrete, masonry mortar and grout etc. was ensured to reasonably clean and free from objectionable quantities of silt organic matter alkali salts and other impurities which are likely to be injurious. It generally satisfied the following requirements.

Designation	Specification
Turbidity - maximum part per million by weight	2000
Public Health value (P.h. value) of water	6.8
Sulphate content - maximum present by weight	0.5
Chloride - do -	0.5

17.2 MORTAR AND CONCRETE

Water to be added to the mortar mixer only when the mortar is required for use and then only in sufficient quantities to make the mix workable and not profuse enough to drown in the cement. The mixed mortar was used in the work before the elapse of the initial setting time of the cement. Mortar and concrete shall be always mixed in concrete mixer machines preferably of the tilting drum type. The proportions shall be as specified for the various works. They are generally as follows:

i) Non-Spillway Section : Water side upto 2.8m depth from front face 1:2 3/4 by volume

ii) Rest of the portion : Cement mortar 1:4 by volume upto certain elevation and 1:5 by volume above that level.

iii) Spillway Section : For impervious face upto the depth of 2.8 m (9 ft) in cement mortar 1:2 3/4 by volume

iv) Rubble Arching : Cement mortar 1:4 by volume

As a degree of flexibility these proportions were allowed to be altered according to the laboratory tests in order to satisfy the strengths specified.

17.3 Replacement of cement by fly ash (Pozzolana) upto 20 percent by weight was allowed. This was ordered to be not only as an economy measure but also to reduce development of shrinkage cracks during the curing process of large masses of cement concrete works. It was also found to improve water tightness and strength reduction was not appreciable. However, in the case of Vaniar project,

no worth while attempt was made to use fly ash as there were doubts about the continuous uninterrupted supply of fly ash at the head works site and the masons too were not quite familiar with this technique. It was apprehended that insistance to adopt this measure would affect the progress.

17.4 SPECIFICATIONS FOR MASONRY

The Superintending Engineer Special Project circle in his Circular No.2690/F208/AE1/dated 06.09.82. communicated the following specifications for strict adherence in all masonry works

The procedure adopted in placing bond stones and face stones in battered face works at right angles to the batter for a distance of 1.5 m from the face should be carefully followed. Bond stones of length not less than 700 mm should be used at the rate of one in every 2.0 m length of face work both front and rear in each course unless the header stones used tail into the work by more than 675mm.

17.5 MASONRY RANDOM RUBBLE FOR HEARTING

The stones are to be set on their flat beds as received from the quarry and without further dressing of any sort other than that of knocking down weak corners and edges with mason's hammers. All stones, chips, spalls etc. shall be washed clean with water before use so as to ensure a clean surface for mortar to adhere to and shall be sprinkled with water before actually placing in the work to prevent absorption of water from the mortar. The stones shall be carefully laid so as to break joints as much as possible and solidly bedded with close joints, the stones must be as heavy as conveniently handled by masons and no stone should weigh less than about 40 kgs. except chips and spalls driven on the sides. No joint shall exceed 40 mm in thickness and be less than 12mm. Mortar should be laid on fresh clean surface after wire brushing flushing with water under pressure and removing all mortar washings etc. The mortar should be worked by trowel to a quake mass and the selected stone laid on this bed and shaken to sink into it squeezing little mortar out at the sides. The stones should then be hammered down by a mallet or hammer of 6 kg weight and pressed towards its neighbours and at the same time without touching them. Additional mortar should then be added to fill the intervening space and well worked by trowel and a light handed bar 12mm diameter 600 mm long to mix up well with the bottom mortar and the stone vibrated to the extent necessary to bring up all excess mortar and any trapped air in the mortar. Then the mortar would then be in a state of a quaking mass, the biggest suitable spall should be driven into the intervening space by a hand hammer 2 to 3 kg. thus consolidating the mortar and squeezing out all excess for use near by again and preventing thick beds of mortar. There must be a good collection of stones and spalls with in easy reach of each gang of masons to enable selections to suit locations in which stones are to be laid and there should be continuously replenished. Inadequate supply spalls would lead to excessive use of mortar.

17.6 The following main precautions should be taken :

i) Avoid underpinning after a stone is laid as this tends to lift the stone off its bed and leave air pockets.

ii) Avoid putting chips in the intervening space between stones before fitting with mortar and shaking it to the full depth to a thick quaky mass.

iii) Avoid putting flat chips at top as these tend to get dislodged easily and in effect, levels up the surface also and drive out all chips to the ends only which will further squeeze and disturb the mortar at the joints.

iv) Keep the masonry surface as rough and rugged as possible to secure good bond between successive layers.

v) Shake the mortar well and vibrate the stone by hand bar to ensure that the excess mortar and water come out and are not trapped at the bottom before driving in chips.

vi) Wire bursh the masonry surface the next day i.e. between 18 to 30 hours after laying so as to remove all laitance excess mortar etc. as cleaning after two or three days is difficult and apt to be inefficient on that account unless carefully and persistently insisted upon.

vii) The work should be so programmed that fresh layer of masonry is started every alternate day.

viii) Restarting of masonry after any long interval should be treated as if on rock surface and dealt with as required in the relevant specifications. In the case of long stoppage of or in any section such as at the end of the morning section or due to any other cause construction joint about 2 m wide and 1 m deep may be left in the surface of the lower section while building the same in order to provide for a cut out and to serve as an additional bond or key between top and bottom sections.

17.7 MASONRY FACE WORK

The face work shall be built of selected stones which are to be sound and free from cracks or joints. Stones with chisel dressed faces or RCC 1:2:4 shall be used for the spillway rear face, piers and abutments while for all other face works, stones with hammer dressed bushed faces will be used. The extent of chisel dressing to be done for bed and sides of stones in each case shall be as described later. The masons should usually work in pairs, one man setting big stones and the other fitting the joints with chips after shaking the mortar so as to clear all air and water by hand bar. The face work shall be built in parallel courses generally 300 mm in height. In case of stones with hammer dressed faces the bushings are not to project more than 25 mm. The distance to which the sides of the face stones have to be dressed square to the face should not be less than 1.5 times the depth of pointing which in turn has to be about 2 or 3 times the thickness of the joint. This fixers the minimum distance of dressing of sides about 70 mm. To ensure water tightness, the face stones in the entire front face as also the rear face of spillway will be one line chisel dressed on bed and sides for 75 mm from the front face. For the rear face of the non-overflow section, the face stone shall only be hammer dressed. In each course the stones shall be built upon headers and stretchers alternatively and joints shall break in the

courses above and below by atleast 100 mm. The stones should be laid on their natural faces and stratied stones should be laid on their natural bed with their strata perpendicular to the pressure which the masonry will bear. In battered face work, the beds of stones and the plane of courses would be at right angles to the batter for a distance of atleast 1.5 meters from the face. The random rubble masonry for the hearting shall be carried on simultaneously with the face work. Great care should be taken to ensure proper bond between the masonry in the hearting and face work consisting of headers and stretchers laid normal to the face batter.

The joints in the front face work should not be less than 12 mm and not more than 25 mm. The joints in the rear face work may be between 12mm and 20mm. Raking and pointing of the front face will be facilitated by the above joints. Bond stones of length not less than 700 mm should be used at the rate of one in every 2.0 m length of face work both front and rear in each course unless the header stones used tail in to the work by more than 675 mm. The position of bond stones should be staggered for the different courses. Such bond stones shall have a faint chisel star marks for easy identification.

17.8 No under pinning of any description is to be allowed and hollow bedding and flushing such gaps with mortar are to be carefully avoided. To ensure water tightness, the front face joints are to be pointed with cement mortar 1:2. The rest of the face work shall be finished off by being neatly struck and smoothed off with the trowel while the mortar is fresh as detailed separately under pointing.

17.9 LEAD FOR MATERIALS

The place and the distance (lead) from which the construction materials were to be brought for the various works in the dam site were generally specified as follows:

Sl.No.	Items	Lead	Source
1.	Cement	18 Km	Bommudi Railway Station The factories were: - Chettinadu Cement Factory, Puliyur - Madras Cement, Thulukkappati - Tamilnadu Cements, Alankulam - India Cement, Sankaridurg - Dalmia Cement, Kallakudi
2.	Broken stone	2 km	From local quarry and excavation and stone for and blasting done for components masonry.
3.	Cut stone, partly dressed	4Km	
4.	Sand	4 Km	Vaniar downstream later a long lead was allowed
5.	Gravel	2 Km	Near hillock in the water spread
6.	Earth for casing of embankment	1 to 3 Km	
7.	Earth for hearting.	6 Km	From Kenkatasamudram

17.10 QUALITY CONTROL

Testing of Concrete Cubes, etc.

A mini testing laboratory was functioning at the head works site during the period when the major construction works were in progress. It was in charge of a laboratory assistant drawn from the staff of the soil mechanics and research division, Madras. A Major portion of his time was spent on ensuring that suitable soils with optimum moisture contents for both the casing and hearting zones of the earth dam embankments are laid and consolidated to the required degree of compaction. His presence was utilised and his assistance drawn in taking cube samples at random while massive concrete works were progressing at dam site and in the casting yard at Pappireddipatti.

Iron moulds to standard dimensions (15 cm x 15 cm x 15 cm for compressive strength of concrete) and 5 cm x 5 cm x 5 cm cube moulds for mortar strength were obtained from PWD. Workshop and stores, Madras and also from the surplus stock of other project divisions.

Samples were taken generally confirming to IS. specifications while the works were actually on. The cubes were identified with different numbers and date. They were taken out of the moulds next day and transferred to water tanks for curing. Tests were conducted after 7 days and 28 days curing periods. Results of tests so conducted were entered in the register kept in the personal and safe custody of the sub-divisional office in-charge of the construction works. Test results furnished in the printed format were also preserved. These records would be useful to prove the bonafides in case of any disputes at a later date. As aforesaid scarcity of cement was experienced during the initial stages of construction in this project. On such occasions, pilferage of cement might take place in the larger scale and adulteration of cement was also likely. The sampling and testing procedures strictly followed as mentioned above were themselves a deterrent against malpractices being attempted in the project works by some unscrupulous elements.

CHAPTER 18
SURPLUS REGULATOR

18.1 GENERAL DESCRIPTION AND NECESSITY

A surplus regulator is an arrangement built in masonry or cement concrete in the dam to dispose off the excess flows realised when the reservoir is nearly full. It is an important component and a must for any storage irrigation system. Otherwise the floods will overtop the bund, breach the embankment and all the water impounded will goto waste. It consists of a body wall for the necessary length, piers, abutments, wing and return walls which wrap round the embankment on either side. It is usually provided withy movable gates (shutters) made of steel plates and iron girders which are operated when excessive flows enter the reservoir. The structure is usually constructed right across the river if sound foundation rock is met with at reasonable depth below the river bed. Otherwise, it is taken to the flanks and a leading channel called, the surplus course is excavated to join the river course down stream. In the case of Vaniar, the latter option is resorted to.

18.2 The surplus regulator should be so designed as to pass on the maximum flood that could reach the dam without allowing the water level to raise beyond a safe limit. This maximum water level (MWL) should be below the top of bund level (TBL). The distance (difference) between these two elevations is known as free board which is determined on certain considerations. While the minimum measurement is about 1.5 m, the maximum is fixed depending upon the wave height, etc. guidelines are available on the Indian Standards Organisation publication No. I.S.10635 - 1993 - First Revision. The technique of arriving at the maximum flood has undergone a lot of advancement. The earlier practice to arrive at the maximum flood was based on a simple universal formula. The parameters involved in this case are only two - viz., the area of the catchment above the dam and a numerical constant which varies from a few hundreds to a few thousands depending upon the catchment characteristics. While some guidance is provided in the hand books for assigning suitable values for the constants, it is usually the discretion of the experienced Senior or Chief Engineer which ultimately prevailed. The maximum flood discharge that had to be tackled by the proposed surplus regulator for Vaniar Reservoir was arrived at after adopting a value of 2000 for the constant C in the Rieve's Formula. The value so obtained as 654 cumecs (23120 cusecs) was verified with reference to reliable flood marks along the river course and calculating the maximum flows that would have crossed the site on a theoretical basis. The figure was found acceptable and fortunately this has not been exceeded till date.

18.4 The modern method is more scientific and rational. It takes in account not only the catchment criteria but also the extreme conditions of the climatology and mateorology of the region. It is explained in greater detail in a later chapter. For the design of the Vaniar Regulator, it was only the old method that was adopted as the advanced technique was not in vogue then - i.e. at the time of formulation of the scheme.

18.5 DESIGN OF THE SURPLUS REGULATOR

The design of the surplus regulator was referred to the Superintending Engineer, PWD Designs, Chepauk, Madras. As aforesaid it was located at the left flank at L.S. 350 m (between 310 m and 371 m) about 910 m away from the river bank. The design was taken up soon after the alignment of the dam was fixed in 1977. Alternate locations on the right side were tried. Boreholes were drilled at L.S. 1296 m and 1308 m. They were drilled upto the elevation of 439.8 m (little more than 20 m depth). Due to the reasons of non-availability of rock at economical depth and also after examining the merits and demerits of both the alternatives the original proposal of left flank surplus regulator was finalised - vide Superintending Engineer (Designs) Madras letter No.A.E.IV/7087/77 dt.01.09.77.

18.6 Sound foundation grade rock was not available in the left flank location too. Soft disintegrated rock (SDR) was met with only at very great depth below ground level on the left side. Hence the design of the regulator structure was based on permeable foundation theory. No cohesive strength was assigned to the base material bearing the structure. Concrete cut-off wall of sufficient depth to arrest the seepage was provided both upstream and downstream. Massive concrete apron of sufficient length to withstand the uplift pressure of water was designed (adopting Khosla's Theory) and provided. This proposal is expensive but in the case of Vaniar Dam at this alignment it was concluded that there was no other less costly and technically feasible option was available. The copy of the detailed design worked out by the Office of the Superintending Engineer, Design, Chepauk for this surplus regulator is annexed with this report. The design features which was adopted were mentioned in the Superintending Engineer, Design's Letter No.AEE/4/7089/77,dated 19.07.1980 and copy of this letter is also attached to this report.

18.7 The other simple alternative of providing an uncontrolled weir - a surplus escape with no shutters was found not economical in this case. The length of the such a weir required to dispose off the designed discharge was calculated to be more than 800 m (see calculation below). Added to this the excavation of a very wide leading channel with necessary energy dissipation arrangements to guide the flood flows and make it join the natural river course smoothly will certainly make the proposal prohibitively expense. Hence this alternative was not pursued.

Calculations (for a Hypothetical Weir in cusecs)

If Q is the discharge, L the length of the weir in feet and H is the head over the crest in feet, for formula the discharge over the weir

$Q = 2/3 \text{ Cd } 2g \times H^{3/2} \times L$

Where Cd in coefficient of discharge (0.62) and `g' is acceleration due to gravity (32.2 ft./sec

Therefore $23120 = 2/3 \times 0.62 \times 64.4 \times 2^{3/2} \times L$

L = 2500 feet m(approx) or 800 m (approx)

18.8 PREPARATION OF PLANS AND ESTIMATE

Detailed site plan with levels were got ready in July 1980 for this surplus regulator in the stipulated location at LS.340 m. This lateral shift was ordered by the Superintending Engineer Projects Circle after studying the site conditions in greater detail. As the shift was laterally done towads river course, along the same alignment and as it was expected to result in savings of excavations for the main work (Regulator as well as in the approach channel for it, the modification was approved by the Chief Engineer. Same drawings which were okayed while sanctioning the scheme estimate for Rs.610 lakhs by the Chief Engineer was adopted for working out the detailed estimates and preparing tender schedules at the division level for the surpluses regulator in the revised locations too. Copy of the above detailed site plan and the drawings of the regulator were sent to the Institute of Hydraulics and Hydrology, Poondy for model studies.

18.9 The plans and estimates were received in the project circle office at Krishnagiri in September, 1980. After scrutiny of these documents, tenders were called for by the Superintending Engineer in December, 1980. Tenders received were evaluated and submitted to the Chief Engineer, Irrigation with recommendations in March, 1981. It is noted that no decision was taken till June that year. Sanction of estimate was also delayed due to revision of schedule of rates after March, 1981 and deferred till the results of model studies were finally known. It was in Chief Engineer's Memo No.P4/15737/79-137, dt.19.06.82. that designs and drawings for a surplus regulator with 3 vents of 11.3 m x 4.5 m was finally approved. The foundation works for the same had however, been taken up much earlier to this date based on tentatively approved and accepted working drawings upto the bottom of body wall level.

18.10 ORDERS OF TENDERS

There was keen competition among the contractors big and small to take part in this large and complex work. There was also an apprehension that if a single agency is involved the works' progress would depend on its whims and fancies which at times might lead to protracted litigations. In that case the project completion will be delayed with attendant postponement in the accrual of benefits and frustration. On the other had if a number of contractors after splitting the work into convenient sections are engaged the progress would be speeded up and the control will be better. There were many representations to this effect. The Government passed orders giving permission to split up the work and entrust the portions to eligible bidders on competitive basis. The tenders submitted earlier for the whole work were returned unaccepted in June, 1981.

18.11 DIVISION OF WORKS

Discussions were held with sub-division staff by the Executive Engineer, Head works and the sections of the surplus regulator which can be handled individually without hindrance to any one by separate agents were identified. The earth work from ground level to foundation level was split into four portions and works put on hand expeditiously and the concrete and masonry

items were divided in such a way as to be distributed among 10 bidders. Many practical aspects were taken into account before deciding upon the broad apportionments of work volumes to the various agencies. They include facilities for implementation, optimum use of the available equipment such as Departmental concrete mixers, pumps for dewatering, compressors etc. The portions so selected were marked in the key plans and drawings of the surplus so selected were marked in the key plans and drawings of the surplus regulator and certified copies taken and preserved in Division and sub-division offices. Quantities of the items were then worked out for incorporation into the tender schedules for the various portions. All these exercise were very expeditiously completed.

18.12 COMMENCEMENT OF EXCAVATION

Short notice tenders were invited for the earth work excavation in the first instance in July, 1981. Agencies were settled and excavations started in August, 1981. Areas of operation of each agency were clearly marked on the ground and careful supervision done by the section staff stationed at Head works site to prevent overlap and conflicting claims. The works were proceeding smoothly and speedily too without any incident or cause for concern. Excavation for this regulator was done manually making use of the hand tools like crow bars, spades, iron pans etc. The overburden were removed and dumped 5 m away from the outer margins like to the excavations of the new surplus course. No blasting of rock was resorted to as there was no necessity for it. The following instructions were issued by the Superintending Engineer, Projects Circle for maintaining the records of foundation levels reached in August, 1980 itself.

Timely recording of levels is quite essential when there are fluctuation of levels between those shown in the approved drawings and the actuals at site. Initial and final levels are to be taken properly by the Junior Engineer and Assistant Engineer and should be checked by the Assistant Executive Engineer.

Executive Engineers are also responsible for any deviations in the foundation levels. They should super check the levels by entering the level readings in the L.F. book (level field book) in their own hands.

Before laying the foundation concrete, a comprehensive plan and cross-section of the foundations were prepared giving the level and check level certificate by the concerned officer. A copy is to be sent to the Superintending Engineer, Projects Site for reference and record purposes.

18.13 PROBLEM IN USAGE OF SAND

The Executive Engineer SM & R division has observed after test of Vaniar sand that it contains organic impurities and should be treated with 6 percent of lime water and then washed and used for construction. This process hampered the progress of work. The Chief Engineer (Irrigation) in P4/61255/81-11/dated 31.10.81. has issued instruction to use Vaniar sand after washing with water for structures where compressive stress are very low.

Finally in Chief Engineer (Irrigation)'s No.P4/61255/B1-13/ dated 22.01.82 has observed that the Executive Engineer SM & R Division has in-

formed that the test results has proved that mere water washing of Vaniar sand is enough and Chief Engineer (Irrigation) issued instruction accordingly that mere water washing of Vaniar sand is enough.

Due to the above reason there was some delay in the progress of masonry works till it was finally settled.

18.14 LOCATION OF REGULATOR SHIFTED

The excavation of foundation to the surplus regulator was taken up in 6/1981. As per the scheme estimate sanctioned the Regulator was to be constructed at LS 245 m to 285 m where the ground level was 470 m (average). But it was shifted to right side at LS point 340 m as per Superintending Engineers No.203M/AE2/dated 02.07.1980 where the average ground level is EL 467. Considerable savings of earth work excavation quantity was brought about and 20,000 ³ of removal of earth worth Rs.5 lakhs was avoided. This was also avoided cutting a leading channel on the upstream side.

18.15 The maximum depth of excavation of about 10 m from EL 467 to 456.8 m was below body wall of ogee curve and stilling basin. No hard rock or sheet rock was encountered and only hard strata of soil was met with in this deep foundation excavation. As the sides opened up were stable, steeper slopes were adopted. This resulted in further savings in earth work quantities.

The excavation of foundation of a quantity of 42,000 ³ was involved when the work of laying concrete was taken up on 03.12.81. The foundation concrete was laid with CC 1:3:6 with graded metal. In Chief Engineer (Irrigation)s No.P/1537/79-112, dated 03.11.81. it has been instructed to extend the cut off from the rear baffle wall to the foundation below the abutment and wings and return to safeguard the structure against the scour. The Chief Engineer (Irrigation during Inspection of site on 04.02.82 (vide CE(I)'s No.P/461255/81-17/dated 23.02.82) has issued instruction that as the length of the regulator in between abutment is only 40 m and the structure is also square no construction joint was necessary. A base levelling course 7.5 cm thick (mud mat) concrete mix 1:5:10 was adopted before laying the apron concrete floor. Where the thickness of concrete for the apron floor exceeded one meter plum concrete was adopted taking advantage of the large quantity of departmental blasted stones available at site. Accordingly the apron concrete of the surplus regulator was laid with plum concrete of 80 percent CC 1:3:6 with graded metal and 20 percent plum (rough stone). This is again a cost saving measure which was satisfactorily complied with.

The abutment wings and returns were constructed in R.R. in CM 1:5. Bond stones of length not less than 775 mm were used at he rate of one in every 2 m length of face work, both front and rear in each course. The Header stones used tailed into the work by more than 679 mm (vide Superintending Engineer's No.2690/F20B/AEI/dated 06.09.82). Every stones should be placed on its broadest face with minimum joints and the joints packed tightly with mortar with sufficient number of spalls of different sizes vide Superintending Engineer's No.1934/82/F68/dated 06.07.82 generally in conformity with the specification already stated vide Chapter 16, paras 16.4 etc.

18.16 CONCRETING METHOD

The maximum depth of concrete was 4.1 m at the stilling basin portion. As the thickness of concrete here exceeds one meter plum concreting was done in layers of 0.2 m to 0.3 m thick and laid in blocks of about 5 m x 4 m x 1 m size each. The adjacent layers and layers one over the other were done with sufficient intervals in between so as to avoid excessive heat of hydration and development of shrinkage cracks. In cases where it was not possible to do concreting with in 15 days time, dowel rods of 12mm dia and about 0.6 m length were provided in the adjacent concrete blocks projecting about 0.3 m length out side at 0.60 m intervals at the top of concrete or at the edges of concrete as the case may be to give a better bondage between layers laid after 15 days intervals. The rate of concreting was about 50 ³ per day. The Chief Engineer (Irrigation) in No.P4/15737/79-134/dt. 21.05.82. has instructed that the baffle wall was to be concreted by raising the concrete apron floor itself to a sufficient height. As there was no mass concrete beyond the baffle portion, there would be no need for centering on one (on the apron) side.

The length of stilling basin was reduced and fixed as 25 m without baffle blocks. The height of cut off wall was increased as 9.5 m from EL 452.5 to 462 m. These modifications were effected after the model studies report was received.

18.17 The body wall of the portion and the upstream and downstream apron and stilling basin were done in CC 1:3:6 with plum concrete. The top portion which had to have contract with water was done in cement concrete 1:2:4 to a thickness of 0.3 m with nominal reinforcement. A reverse (+) like depressing was left immediately after the spillway body wall to house the extensions of reinforcement and oghee template centring and to provide support for these items. The method of providing foundation embedment in the concrete for purpose of fixing centering of the ogee curve concrete was done satisfactorily and efficiently. The oghee surface obtained was also fairly good vide Superintending Engineer's No.1493/76/F503/dated 20.05.83.

18.18 Test cubes were made of each concrete mix and tests conducted and result tabulated and kept at site as per Superintending Engineer's instruction No.2661/D4 dated 07.12.81. As per approved drawing then a loose pointed protected block aprons and launching aprons both upstream and downstream had to be provided out. Chief Engineer (Irrigation) during inspection of site on 24.08.82. instructed that judging from the nature of soil the loose jointed aprons and launching aprons both on upstream and downstream sides need not be provided. Transition wall in continuation of the wings of the regulator originally proposed was deleted in view of the hard strata of the soil. Instead he has instructed to provide a rough stone bed pitching glacis with 1 to 3 slope for connecting the apron with the existing ground level vide CE(I) No.IN PC/83-17/dated 24.01.83. However returns were provided at the end of the wing walls in masonry connecting the excavated face.

The sequence of work adopted in building the surface regulator is shown in the sketch in the opposite page.

18.19 Two utility towers of size 4m x 4m internal and 6m height above TBL have been constructed on either end of the regulator to add appearance to the structure and also to provide access to the operation platform where hoist equipment are located. The additional masonry needed to create the space for the utility tower was built with R.R. in lean cement mortar resting over the massive abutment body wall below to reduce the cost. In one of the towers the diesel generator and the control panel board were housed while in the other the flood stock materials are kept. The 30 KVA generator can be made use of in case of failure of E.B. power supply.

18.20 One reinforced cement concrete T-Beam deck bridge having 3.65m wide roadway was constructed over the regulator piers. This is provided with 1m height RCC parapet wall with ornamental perforations in either side. Masonry steps are provided starting from either end of the road way to reach the trunnion axis housing for inspection and maintenance purposes.

18.21 BED BLOCKS - DESIGN AND CONSTRUCTION DETAILS

Basically the bed blocks were designed for maximum uniformly distributed load - reaction - from the RCC twin tee beam deck slab grider with 0.725M on clear over hang on either side, the bridge having been designed as a single lane bridge for Class A loading using IRC bridge codes, Sections I, II and III and Highway Manual Volume II, Part II. The concept is simply supported beam with over hangs as above and 1.750 m clear span in the middle. Cross girders were provided as per the Chief Engineer's Memo No.P4/15737/79-151 dated 08.10.82. The over all dimensions of the bed block are 4 m x 0.8 m x 0.6 m (depth). Five numbers of 16mm TOR steel were provided both at top and bottom for each of these bed blocks which rested on smooth beds on the two piers and the two abutments. Four legged 8 mm diameter TOR steel stirrups were used along with 25 mm pillets to hold these main rods in position. Neoprene bearing pads of 400 x 400 x 15 mm size with hardness not less than 50 were placed centrally over each bed block to support the 400 mm wide ribs of the bridge girder.

When the piers and abutments reached the level of 471.40m, the tops were finished smooth and then the shutterings were made ready. The reinforcements were placed in position over the precast cement concrete fillets of thickness equal to the clear cover specified. These fillets were hung on the sides also. The concrete was placed in layers of 15 cm to 20 cm thick and each layer was compacted using vibrators activated by compressed air. The final thickness (depth) achieved was 60 cms. Before the reinforcements and centering for the bridge girder were got ready the neoprene pads were placed in the exact positions over these bed blocks after applying fixing solutions to be contact surfaces. There was a gap of 400 mm in the bottom centering plank of the ribs at which the neoprene pad was housed. The thickness of these planks was 15 mm and hence there was no question of escape of cement slurry during insitu casting of the beams and deck slabs. When the centerings were removed the loads get transmitted directly to the piers and abutment masonries, with intensities well within the safe bearing capacity for random rubble in cement mortar 1:4. The construction details of the bed blocks and road bridge are shown in the drawing approved in Chief Engineer's Memo No.P4/15737/79-151 dated 08.10.82. This drawing is annexed to this report.

CHAPTER 19
SURPLUS COURSE

19.1 To dispose off the flood surplus water of the order of 654.9 cumecs (or 23150 cusecs) passing over the surplus regulator a surplus course is found necessary for a length of 1250 m to reach the regime section of river Vaniar. The confluence point is located about 500 m downstream of the earth bund. Since the new course takes off from the flank and follows a curved alignment its length is more. The terrain of the ground is falling from the left flank and towards the river portion. The ground level difference from stilling basin of surplus regulator to the river bed is 20 m (461.3 to 441.63. To negotiate 20m level difference, 2 m drops ten numbers were constructed at suitable points.

A land width of 150 m throughout was acquired and a total extent of 33 acres were taken over for the formation of the surplus course.

19.2 The main working seasons pis from January to June about seven month since the area of working is at the foot of the Shervarayan Hills which is subjected to rains by both during south-west and north east monsoon (July to December). Therefore, the work of excavation of surplus course was programmed to suit this seasonal condition. The surplus course originally designed had a section of 56m x 5m which was envisaged in the scheme report. However, to have a economical section, model studies were conducted at Irrigation Research Station, Poondi. In the mean while to avoid loss of time the excavation of pilot channels in the middle strip of the surplus course was taken up in October, 79.

19.3 After conducting model studies, the Chief Engineer (Irrigation) issued instruction in No.P4/15734/79-15/dated 28.02.80 that the permissible velocity of 8'/sec. (2.44 m per sec.) for soil like SDR and Kankar should not be exceeded. The Superintending Engineer, Design Circle has designed the section as 53 m x 5 m with a bed fall 1/2960.

The Chief Engineer (Irrigation) has approved the same in P4/15737/79-132/dated 02.03.82 and the following are the hydraulic particulars of the final section of the surplus course.

Bed width	-	53 m
Side Slope	-	1:1 (in cutting)*
Bed fall	-	1 in 2960
Maximum Depth of flow	-	5 m
Calculated discharge	-	675.5 cumecs
Length of surplus course	-	1220m

Note: The side slopes were later made steeper (as 1/2 to 1) as per instructions of the Chief Engineer during camp. The site conditions were amenable to effect this economical measure.

The design of the surplus course was studied in a composition model. After a series of trial runs a sunk type stilling basin 1.4m deep and 12.45 m long was recommended below the regulator. The crest of the body wall should be 2 m height and 2.5 m width at every drop site to get the required depth of flow in the surplus course was proposed.

The Bed width of the surplus flows as per original scheme report was 56 m and the same was reduced to 53 m as per recommendations of the Research institute resulting in a saving of 37,000M³ of earth work which is 10 percent of the estimated quantity.

19.4 The depth of flow in the surplus course at MFL will be 5 m and the course runs in full cutting except near the drop points. To withstand the maximum flow it is necessary to form the bank with 30 to 34 m base width. The average depth of cutting will be 3.5 m and the area of cutting will be 53+62/2 x 4.5 = 2.5M². The banks with a base width of not less than 30 m to 34 m and 6.5 m height giving suitable berm in both front and rear of the banks were formed utilising the excavated soil.

19.5 A curve in the surplus course with a radius of 15 times of bed with (R = 15 x D) has been introduced. The curve starts from LS 850 m onwards.

19.6 EXTRA RATE FOR EARTH WORKS IN SURPLUS COURSE

The contractors who were excavating th e surplus course have represented to Superintending Engineer on 26.08.80 and to Chief Engineer (I) on 09.01.81 during their inspection of site that the work load involved in removing certain rocks requiring blasting in the surplus course in certain reach is found harder than MR and DMR requiring blasting but not hard rock. The rate of 11.80/M³ as per schedule of rates 1980-81 for this time was found unworkable and put much loss in blasting of this variety of rock. The Chief Engineer(i)'s No.P4/15737/79-61 dated 23.01.81. has instructed that a special rate may be approved by Superintending Engineer after due observation.

19.7 Necessary observed data was approved by the Superintending Engineer, PWD, Special Project Circle Krishnagiri in No.586/F63-A/D4/dated 12.03.81 for medium hard rock requiring blasting and stacking the materials for measurement within initial lead and lift as Rs.16.50/M³

19.8 As no contractor was willing to execute the work at the ceiling rates for excavations in various soils approved by the Superintending Engineer in No.533/80-D3/dated 19.04.80 and 788/F63/D4 dated 28.05.80, the reaches were split up into so many convenient parts and works entrusted on nomination at ceiling rates to job workers.

19.9 As per the design approved the total quantity of earth to be excavated for the surplus course was about 3.55 lakhs M³ as against 4.0 lakhs M ³ in the schemes estimate. But due to change in soil classification and the ceiling rates adopted after finding out that the normal schedule of rates were unworkable, the cost of surplus course has exceeded the scheme estimate amount even

though the quantity was less. Because of the hard nature of the soil 1/2:1 slope has been adopted as per CE(I)'s No.PC/82/2/dt.8.08.82 instead of 1:1 as per approved design. The whole work of excavation was completed by 1982 covering an average of 1000M³/month.

19.10 DROPS IN SURPLUS COURSE

19.10.1 Description and Necessity

A drop is masonry structure like a short weir with a small stilling basin put up across a water course to smoothy negotiate the difference in bed levels in front and rear of it. When a new course is taken along a steeply slopping gradient, its bed level cannot follow the same gradient throughout. Since over such steep slopes, the flowing waters will pick up tremendous velocities which will erode the bed and sides badly. After a few seasons the scour moves upwards the channel and endangers the structure at its head. This phenomenon is known as retrogression. And all hydraulic structures coming up along a water course should be guarded against this development.

19.10.2 In the case of Vaniar the ground level immediately after the surplus regulator was about 20 m above the bed level of the natural river at the confluence point. The distance is over 1200 m (4000 ft.) If it is joined straight, a slope of 1 in 60 would have to be adopted such steep slope will induce tremendous velocity. Hence stepped formation of the course with smoother slopes had to be resorted to. The reaches are at different elevations each progressively coming down. At the end of every such reach a drop is constructed. In the case of Vaniar 10 such drops are built each negotiating a fall of 2 m (about 6 ft. 6"). After comprehensive model studies are done before the slopes of the reaches and stilling arrangements after each are designed and constructed. The resulting flow conditions everywhere and at the confluence with the natural river are such that the velocities are neither excessive to cause scour nor too low to allow silt accumulations. These are however, general requirements. Some minor modifications to suit the actual site conditions met with in the new course of surplus at Vaniar were introduced after site visits. The changes are mentioned in the following paragraphs.

19.10.3 Originally when the scheme was under examination, in 1978, 2 number of 4 meters drops and 6 numbers of 2 meters drops were proposed and in fact the scheme estimate was sanctioned agreeing with these proposals. But later the concept changed and the practice in 1980 was not to go in for drops more than 2 meters height due to considerations of stability etc. and finalise the design after model studies. This decision was conveyed in Chief Engineer (I)'s Letter No.P4/15737/79-49, dated 26.09.80.

19.10.4. After conducting Hydraulic Model studies 10 numbers of 2 m drops have been proposed to be constructed at L.S. points. 100 m, 140 m, 180 m, 300 m, 410 m, 540 m, 585 m, 685 m, 888 m and 1175 m along the alignment of the surplus course. The Superintending Engineers during inspection of site on 14.04.81. has introduced that the drop at L.s. 685 m may be shifted lower down to 700 m so that it can merge with the acquiduct for the left side canal crossing the surplus course and thus curtail the expenditure to a tune of about Rs.50,000/-

19.10.5 The Superintending Engineer Design and Executive Engineer, IRS, Poondi have visited Vaniar Reservoir Project Dam site on 07.11.81 and observed that for all the drops water cushion may not be necessary and 0.5 m height baffle wall located at 11 m from the toe of the drop would suffice. This was approved in Chief Engineer (I)'s No.P4/15737/79/133/dated 07.04.82 and the same was adopted in construction.

19.10.6 For the drop at LS 300, a slopping baffle to match with the super elevation of curvature of flow has been made with 0.2 m height at the inner curve side and 1.25 m on the outer curve side vide CE's No.TA/5/TO/R.O.5416-2/dated 15.05.82. The surplus course at LS 180 is in a curve below the body wall and to suit this condition the rear wings are constructed in a curved manner. Immediately below the body wall in the left side, rocky out crops were met with which protruded 1 to 2 m above the rear bed level and this would acts a baffle wall and would deflect the flood water to the right where there is no such out drop of rock. As rock is met with in the rear no baffle wall has been proposed in this drop.

The 2 m drop design was approved in Chief Engineer (I)'s No.P4/15737/79-132/dated 02.03.82.

19.10.7 The toe wall which was shown in the apron drawing upto the front face of the downstream return only was later taken to the full length of the return as provided in the case of the surplus regulator to safeguard the structure under the worst conditions. The section of the body wall was provided to the required width (i.e.) 3.55 m bottom width with 5.9 m height.

19.10.8 For keeping the continuity of masonry course the depth of foundation concrete for upstream wing and returns was provided as 0.8 m against 0.6 m provided in the approved drawing. Below the body wall and abutment the vertical faces of earth has been sloped to 1/2:1 to negotiate with apron concrete level.

19.10.9 The horizontal spacing of weep holes has been kept as 3 m to suit the site conditions and practical aspect. As the height of the body wall of drop is about 5.9 m it was very difficult to move about for inspection purpose. Therefore steps with 750 m width in RR masonry in CM 1:5, plastering with CM 1:5 on the slopes on the right side and both in upstream and downstream sides of the ten drops have been provided.

19.10.10 Departmental store sheds were constructed with light roofing materials and thatched roof at each drop site for storing cement and other materials required for the construction of drops in question. Since the main store shed which was at 1 km distance is for storing all the materials required for the entire head works and the day to day issue of materials to several works from the main store was not possible. Individual sub-stores as above were put up near the various work sites along the surplus course. Therefore the materials required were issued from the main store to the concerned section officer and the section officers were keeping the materials in the sub-stores and issued them for day to day work.

19.10.11 During actual execution considerable saving was achieved by adopting plum concrete for apron by using 20 percent of departmental blasted stones and 80 percent cement concrete. Since the thickness of apron is more than 1 m that is 1.75 m the above economy measures was found feasible. Further, except the four drops at L.S. 100, 140, 885 and 1175, all other drops at L.S.180, 300, 410 540, 680 and 710 are located on rocky bed portion and stilling basin concrete are reduced or omitted according to the site condition. All the baffle wall provided in the drops are of cement concrete 1:2:4 with nominal reinforcement.

19.10.12 The series of the acqueduct for the left main canal crossing has been constructed over the stilling basin concrete of drop at L.S. 710 m and thereby the foundation cost of the aqueduct was minimised by constructing the drop at L.S. 710 m as drop cum acqueduct. A photograph showing this arrangement is shown in the opposite page.

19.10.13 Leads, Lifts, Ramps, etc.

In Embankment Earthworks : The earth from cut-off trench was conveyed manually to places beyond the outer line of the toe drain all along the alignment. Considerable quantities were dumped pin local depressions quite away from the down stream toe. Much of the harder stuff was used in forming the haul road over which the heavy earth work machineries moved to reach the earth dam embankment on the left side between the hillock and the deep river bed. With the lead distances increasing beyond 50 meters this method was found to be time consuming. The lift also becomes greater when cut-off trenches of depths larger than 5 to 6 m were to be tackled. In such cases lorry transport was resorted to.

Earthen ramps were cut along the sloping sides of the cut off trench at approx. every 10 m to make the movements of the labourers carrying head loads of excavated soil easy. The gradient of such ramps was not more than 1 in 12. At the places where the trenches were deep, zig-zag pattern (dot legged type) ramp was formed as and when the excavation works were progressing steps were cut in these earthen ramps for the convenience of the mazdoors. No mechanical excavators were employed in the trench formation, Make-shift hand railing with casuarina poles and ropes was formed along the outer edge of these cut and formed ramps. No accidents were reported during any time the ramps were in use.

Lifts and leads over and above the initial lifts of 2 m and initial leads of 10 m were paid for at the schedules and agreed rates and the lorry conveyance at he competitively quoted unit prices. Lorries entered the cut-off trenches in the deep reaches from either ends. The exit slopes here were formed to the gradient of 1 in 15. The earth in the gaps between the adjoining reaches on either side was excavated and lifted off manually, loaded in to waiting lorries and disposed off as shown. The maximum lift involved was of the order of 14 m to 15 m. The haul distances for the heavy earth moving equipment of Tamilnadu Public Works Engineering Corporation (TAPWEC) which were en-

gaged in bringing suitable soils for impervious and semi pervious zones of the dam embankment varied from 1 to 3 km. As mentioned before, care was taken to locate the borrow areas for earth for hearting the casing zones as near to the dam alignment as possible.

In Masonry Construction : In the initial stages of the foundation and sub-structure works involved in the surplus course and regulator, the ramps cut along the excavated sides as before were used for removing the excavated muck and transporting i.e., taking down mixed concrete, mortar and rough stones for building purposes in the regulator and surplus course sites. However, for the two tower head sluices, wooden steps formed at different evevations in the scaffolding served the purpose. The scaffolding was accommodated in the working space of the sluices's well and the barrel. The labourers standing one over the other on these steps cleared the foundations off the muck etc. and sent down the materials for building up the foundations and sub-structures. The deepest portion tackled was 9.6 m from the ground level under the cut-off walls of the regulator. As the body wall of the surplus arrangement consisted of stepped foundation the longitudinal approach from the down stream side came in handy for completing the massive excavation and concreting works involved here.

As the masonry in the body wall of the regulator rose above the ground level scaffolding with double rows of casurina poles was erected and extended vertically every time to match the height of the wall everywhere. The poles were tied securely at all joints by coir ropes so that the whole acted as an integrated unit. The working platform for the masons at convenient elevations were formed in this scaffolding network itself by securing thick wooden planks with the horizontal poles by means of wire nails and ropes. The curved nappe portion of the spillway had to be tackled carefully. For this area 18 mm dia. steel rods were embedded and left projecting during construction. Two rods at close intervals were left at suitable horizontal spacings to serve as supports for the verticals. Working platforms were secured to the scaffolding at operational levels close to these twin rods leaving such space as necessary to finish the top surface strictly conforming to the specified curve. After completion of the work and curing time, the rods were cut off flush and the joints pointed smooth with 1:2 cement mortar. No rods or nails were allowed to project anywhere on the surface coming in contact with the flowing water.

The erection of gates and operating platforms were done by the PWD workshop technicians who used derricks, winches and gantry cranes for that purpose.

CHAPTER 20
TOWER HEAD SLUICES

20.1 DESIGN REVISED AND ADOPTED

Two tower head sluices one on the left side at LS 735 m and other on the right side at LS 1310 m have been constructed based on the design finally approved in Chief Engineer (I)'s No.P4/15737/79-98/dated 13.07.81 and PA/15737/79-101/dated 28.07.81. Earlier the investigation wing have forwarded a design in which R. R. masonry barrel was proposed. When a competitive cost analysis was done in Chief Engineer's office, it was established that a sluice with RCC barrel was cheaper than the design with R.R. masonry barrel. The R.R. masonry barrel side walls were massive. The thickness of RCC barrel sides and top worked out to 40 cms only. Cost of barrel with masonry side wall worked out to Rs.4.27 lakhs whereas the cost of RCC box type barrel worked out to Rs.3.22 lakhs only. The standard barrel dimensions normally followed by Superintending Engineer Design's Office are (i) 0.9m x 1.5m (3 ft. x 5 ft.) (ii) 1.5m x 1.8m (5 ft. x 6 ft.). Since the first can discharge 2.124 cumecs (75 cusecs) at the minimum hydraulic head of 0.3 m (1 ft.) the later one was adopted for the Vaniar sluices. The discharge for this size is 5 x 4 x H = 5 x 5 x 6 x 1 = 150 cusecs. Required discharge in 79 cusecs for left only and 86 cusecs for the right. The sill levels of both the sluice were fixed at +451.10 m with vent size 1.5m x 1.8m

20.2 Load test were conducted by the staff of the Soil Mechanics and Research Director, Madras at the left side sluice site at LS 735 m on 05.03.81 by excavating a pit of 2m x 4m EL 449.2 m. Similar load test was conducted at the right side sluice at LS 1310 m on 08.03.81 by the same party. After these tests and after analysing the results, the Executive Engineer S M & R Division reported in No.SDL/211/80/dated 11/03/83 that the soil in both the locations is soft disintegrated rock. The tests were conducted after saturating the soil and no failure has occurred in both the locations upto a pressure of 10 kg/CM² and the load bearing capacity was therefore arrived at 10 kg/CM² or 100 tones per M². The maximum pressure below the tower base worked out to 31 kt/cm². This have a big margin. Undisturbed soil samples could not be collected since the soils is of SDR variety at foundation level.

20.3 CONSTRUCTION STAGES

20.3.1 Preliminaries

Estimates for the two tower head sluices along with draft tender schedules were submitted to the Superintending Engineer in January, 1980. The estimated value was Rs.15.0 lakhs each. Tenders were called for fixing the last date as 20.03.80. Advance payments for sluice shutters, C.I. liners etc. were made to TAPWEC and CI liners were supplied by the corporation immediately. While the bid for left side sluice was settled at Chief Engineer's level, those for the right side sluice (near right flank) were sent to the Government for acceptance in April, 1980. In the means time some modification in the estimated quantities and drawings were discussed in view of the shifts in the loca-

tion. The right side sluice was positioned too lose to the hill slope where the chances of loose boulders slipping and blocking the leading channel were apprehended. The tender for the right side sluice was received from the Government in early June, 1980.

20.3.2 Work Delays

Part of the space required for the left sluice was in patta lands. Hence the works here were delayed till crop compensation was paid. But in the front portion works were started in right earnest in right earliest in April itself since this section was within poromboke limits. The commencement of works on the right side did not take place till January, 1981 in view of the blasting activities on the mountain slopes. In fact the progress on both sites was not a fast as expected largely due to interruptions of rock removal works for cut-off trench in the barrel portions and also for the river diversion. Formation of the fitters and rock toe and toe drain in the alignments of the barrels of these sluices did also contribute to the slackness. The rates in the agreement quoted long back were found unworkable by the Contractors. All these causes got compounded and resulted in the cancellation of the agreements. However, before the termination, foundation concrete work for the right side sluice was almost completed in March, 1981.

20.3.3 It was during January and February, 1982 only fresh estimates were prepared incorporating the design changes and got sanctioned. Fresh tenders were called for evaluated and sent to the Board of Engineers for acceptance. The tenders were accepted in May, 1982 and the works were resumed. The balance excavation works in the left side sluice had to be completed by local bidding procedures (piece work contract system). Since this item was excluded in the fresh tender for this work. This was over only in early July, 1982 and the new contractors stepped in afterwards. For August, 1982, the achievements were as follows:

RCC base concrete	Total quantity involved (in both the cases)	470M³
Left side sluice	Target	200M³
	Achievement	75 M³
Right side sluice	Target	300M³
	Achievement	107M³

20.3.4 The progress of these tower head sluice was very much affected due to acute shortage of cement during the months October, 1872 to February, 1983. The works were at a standstill during the major part of the above period.

In mid-May, 1983, unprecedented heavy rains resulted in the flooding of the excavated trenches of these works. Heavy duty pumps had to be

employed to dewater the portions in which the constructions had not reached ground level. Clearing thoroughly the muck etc. which had settled over the concrete surface and wire brushing them etc. further delayed the completion.

In June, 1983, the progress was noticed to be slow. The steel liners for the sluice gates and emergency gates were being embedded in the concrete that time. The time escalations noticed that time were causing concern. This could be gauged by the following remarks of the Chief Engineer (Irrigation) who inspected the dam site on 07.06.83. Both the contractors may be asked to haten the construction of the tower heads so that this does not hinder the progress of the earth dam. If the response is poor, the Superintending Engineer, may do well to fine them for slow progress.

20.4 The tower head wall of the sluice was constructed in CR masonry II Sort in C.M. 1:4 and the dia of the wall is 3 m and the height of the wall is raised to TBL 474.0 The wall was approchable from the top of bund through a RCC bridge of 3.6 m wide supported on RCC columns over the RCC barrel. The barrel of the sluice was constructed in RCC 1:1:2, 40 cm thick to a size of 1.5m x 1.8m cut off collar with CC 1:3:6 were provided at 10 m intervals.

20.5 The usual cut-off trench below the sluice portion was dispensed with and instead a smaller cut-off trench with 1 m width and 3 m top width was excavated upto d/2 and filled with plum cement concrete 1:3:6

20.6 The services gates are of size 5 ft.x 6 ft. and as the maximum lead of water is 20 m cast iron liners have been provided for the grooves. The emergency gate is of size 7 ft. x 8 ft. to make it heavy enough to go down against the uplift when lowered. Only one emergency gate is provided for the two shutters.

20.7 Gantry cranes were provided for the operation of the emergency shutters. The shutters groove frames, lifting equipment and gantry cranes were designed and manufactured at the Public Works Workshop at Madras and assembled and erected in position by their crew at Vaniar.

CHAPTER 21
SADDLE ANICUT AT THE LEFT FLANK END

21.1 A suggestion put forth by the Executive Engineer during the inspection of thee special officer attached to the Chief Engineer's office on 25.09.79 to provide a saddle in the left flank was well taken and acted upon. It was about creation of additional surplus capacity at a very nominal cost taking advantage of the topography at the left flank end.

21.2 A saddle or byewash as it is commonly know is a low valley through which the flood waters escape when the level reaches little above the full reservoir level. It is usually paved with concrete or random rubble masonry for a short distance (to avoid retrogression).

21.3 At the dam site a low ground existed between chainage L.S. 80 m and L.S. 120 m and a natural stream was taking off from this point. This site was approved by the special officer on inspection and he suggested that a saddle for a width of about 40 m be located at this place.

21.4 Accordingly a saddle anicut of 30 m length was provided by building a R.R. masonry pavement for a short distance at the left flank end with crest level at 471.30 (i.e. 30 cm above FRL). The natural ground after this paved bywash was trimmed with a gentle slope to join the existing odai. Unprecedented floods realised time when the gates could not be operated properly can pass over this saddle. This can discharge about 30.2 cumecs (1064 cusecs) with 0.7 m (2.3 ft) flow over the weir wall. The flood waters are passed through a natural odai and finally falls into the surplus course. A wrap round wall in R.R. masonry in cement mortar 1:5 was constructed as bank protection for one embankment starting from L.S. 120 m.

21.5 GENERAL

21.5.1 Cost Escalations and Attempts to Cut Down the Costs

After the reappraisal done in early 1983, it was apparent that the project would cost almost twice the original sanctioned estimate. A number of deviations had come in during the execution and the provision made for certain components like the surplus course in the original estimate had been rather poor. However, in view of heavy expenditure incurred on such deviations, care should be taken to keep the Government informed of the reasons for the large excess over the sanctioned estimate. The project staff was required to keep to mind that large increases would be questioned at all levels. Hence Superintending Engineer Project Circle was directed to inspect the works in surplus course frequently avoid expenditure on removal of hard stuff and effect saving in the drop structures wherever possible taking decisions at site. Conscious efforts were called for from the Executive Engineer level also to economise on the cost of surplus course which was a high cost item of the project.

21.5.2 At the confluence of the surplus course with the natural river construction of banks and protection were suggested by I.H.H. Poondi. As the left

bank of the surplus course was cut in hard material, no additional protection was required and the face was dressed half to one slope and made to join the left margin of the river tangentially. The right bank was suitably formed to drain the flows into the existing river course. The original course above this confluence was then plugged by dumping the surplus soil available on its banks. This was another instance of economy measure consciously introduced.

21.5.4 Expenditure Incurred

The actual expenditure incurred and the corresponding scheme provisions for the major components of the project are as follows:

Sl. No.	Items	Scheme Provision (Rs.)	Actual Expenditure (Rs.)
1.	Earth Dam	1,01,00,000	2,89,99,698
2.	Lands	12,20,000	24,32,449
3.	Works (Tower Head Sluice) (River Sluice)	23,75,000	2,12,58,882
4.	Surplus course	58,00,000	41,99,052
5.	Spillway (Surplus Course)	39,00,000	1,26,36,657
6.	Machinery and Equipment	44,58,000	46,80,300

21.5.4 Suspension of Work due to Power Cut and acute Shortage of Cement and Unusual Raining

Around the end of 1982, shortage of cement hit the progress on all sides. The regulator site, drops in the surplus course and the sluices of the dam were a desolate look. The dismal period lasted from October, 1982 to February, 1983 during which period no cement could be acquired from the factories. Works were at a stand still after 15.12.82. As an amelioration measure the contract labour who were idle were engaged in earth dam formation at the flanks and on either side of the surplus regulator. The earth work assigned to TAPWEC were reduced to this extent and the machinery were diverted to other reaches. This gesture was shown to keep the labour force familiar with the project works intact. When the works resumed after cement arrived at site the benefits of continuity could be relied upon and the progress was expedited with the intention to make good the shortfall in the target.

CHAPTER 22
ERECTION OF GATE HOISTING EQUIPMENT ETC.

22.1 GENERAL RESPONSIBILITY OF THE WORK

The work of design, fabrication, shop testing, supply, erection and testing at Vaniar dam site of the gates - both the sluice gates and the radial shutters for the 3 (three) spans of the spillway, fixed gantry and hoisting arrangements etc. complete were left to the responsibility of the Public Works Workshop and stores division, Madras. This organisation of the State PWD has the necessary expertise and long experience in handling specialised jobs of this nature. To start with for some years from the late seventies this stores and workshop division was functioning as an unit of Tamilnadu Government Corporation on commercial lines. But since March, 1981, it again became a part and parcel of the PWD. Though strict undertaking in leval terms in writing for the guarantee and warranty of the manufactured and erected equipment in this regard could not be taken compliance to standard specifications for the raw materials used and the electrical motors accessories etc. were always available. It has however, to be observed in this context that works undertaken by them at Vaniar were effective and economical and compared favourably with the similar jobs at Kodaganar handled by the Thungabadra Steels.Ltd. a commercial concern under the control of the Government of Andhra Pradesh. There is always the tacit understanding that whenever any defect or repair crops up, the Superintending Engineer, Workshop and Machinery circle is addressed and the equipment is set right on actual expenses basis. So far no insurmountable problem aroused in the operation and maintenance of the gates in the Vaniar Dam spillway and sluices. All the erection works were carried out by the skilled technicians and workers of the above division under the direct and frequent supervision of the qualified engineers of the Department. A full fledged machinery sub-division was functioning at the dam site and higher supervision, direction and control were provided by the machinery and workshop division at Trichy and the Superintending Engineer PWD Workshop at Machinery Circle, Madras.

22.2 The job comprised the following:

Design manufacture and erection and testing for good performance of

i) Spillway crest radial gates for three vents of size 11.3 m and 4.5 m each consisting of M.S. skin plate vertical stiffeners, two sets of fabricated girders with inclined arms inter-connected with L angle bracings welded at one end to the steel beams which in turn having been welded to the stiffened skin plate and at the other end converging to thick hub plates for transferring the water thrust to the heavy moulded C.I. hub assembly with liners and sill beams.

ii) two lift gates for the tower head sluice of size 1.5m x 1.8m with liners and sill frames including; fabrication of these gate leaves into loadable units, transporting and erection at site.

iii) Electrically operated rope drum hoists for the spillway radial gates consisting of the central drive units two numbers of gear box assemblies with shafts plumber blocks, couplings and indicator unit with limit switches, necessary electrical motors and accessories.

iv) Wall plates extension to sill beams, diaphragm plates for trunnion girders including drilling of holes for fixing of brackets with bolts and nuts as per schedules supplied.

v) Fabrication of embed parts, transportation and erection of them in place in the dam masonry components.

vi) Moulded C.F. pedestals - 2 nos. for each gate with drilled holes, heavy bolts and nuts, transport and erection and

vii) Manufacture all hoist and deck bridge parts including steel chequered type M.S. plates for the platform and hand rails, transport, assembly and erection at site.

viii) Rubber seals along with special liners the bolts and nuts and space plates, etc.

22.3 SPECIFIC REQUIREMENTS OF GATES AND ACCESSORIES

22.3.1 The gates to be manufactured to suit the clear openings specified. The actual dimensions of the gate will be decided by the manufacturer providing due allowance for the guides, grooves, water seals, etc.

22.3.2 **Gate wheels** suitable device to lubricate the wheels on the sides of the main sluice gates and the emergency gates and wire rope pulley blocks and the pick up hook fixed to the bottom corner portion of radial gate should be provided.

22.3.3 **Guide Rollers.** The gates fitted with spring loaded guide wheels or other suitable devices which should function more efficiently are to be fixed. It is to be ensured that the gates enter the openings truly parallel to the side tracks.

22.3.4 **Seals.** Gate seals for water tightness are provided all round (i.e. the two sides and the bottom in the case of radial gates and lift emergency gates and along the four sides in the case of sluice gates. Gates are to be perfectly water tight and all conditions. If any special devices are proposed to be installed they should be so stated with source of purchase, manufacture, previous usage reference and guarantee etc.

22.3.5 **Embed Parts.** The portions of the gate shafts or the piers and abutment sides which are to carry the guide plates or angles are to be of RCC. The shop working drawing shall show the positions and give approximate dimensions of these grooves and chases to be left during construction and indicate the method of fixing supports for the guide angles and plates. Hoists with winch motors should be on the top of platform supported by girders resting on piers and the ropes will pass over guide pulleys.

22.3.6 **Manual Hand Crank** should be provided with storage position for it clearly indicated. Rope drums and open gears shall be protected by a metal cover.

22.3.7 **Block outs and Grooves** will be provided by the civil construction agency. These will be formed in advance in the sluice well shafts for the installation of embed parts. Suitable chases and grooves shall be left for all the sills of the guides and guidelines, roller parts, foundation bolts of these accessories. Similar chases shall be left for guides of dogging beams and gantry and gate trunnion pedestals, etc. to the sizes shown in the drawings. Complete working drawings furnished by the manufacturers and suppliers are to be always maintained at the sites of erection.

22.3.8 **Hoisting Equipment.** These items shall be complete with all electrical and mechanical accessories and fittings. The hoist should be provided with weather-proof metal cover. Further it includes the following :

a) Electrical Motors of suitable capacity for operation under 400/440 V 3 phase 50 cycles AC power supply and also withstand minor flunctuations of the voltage.

b) Contact gear

c) Solenoid brakes

d) 3 point push buttons (i.e., Raise, Stop and Lower)

e) Inter-locking arrangement for automatic cutting of supply when the hand crank is engaged for operation and vice-versa.

f) Reduction gear heads of shaft with wirings, wire ropes, etc.

g) Position indicators (indicator lamps for the closed and open position of the gate are to be provided). Ammeter and Volt Meter are to be provided in the panel board.

The gate erection works in Vaniar dam site proceeded on steadily satisfactorily complying with the above requirements. A general ideal of the radial gate assembly and the sealing arrangements are given in the opposite page.

CHAPTER 23
VANIAR RESERVOIR PROJECT CANALS

23.1 ORGANISATION AND PROGRAMME

Vaniar Division was formed on 06.06.79. to carry out the scheme with four sub-divisions. The division was located at Harur and all the four sub-divisions were stationed at Vaniar Dam site and one sub-division was looking after the canal works till a separate division was formed.

23.2 Vaniar Division II was formed on 23.09.80 exclusively to carry out the canal works. The division was located at Harur. Two sub-divisions had headquarters at Pappireddipatti, a third sub-division at Harur was initially looking after the construction of quarters, division office in addition to the canal works.

23.3 During 9/80 to middle of 1981, the investigation of canal works, preparation of condensed L.S. construction of quarters at Harur and construction of Division office at Harur were being attended to permanent Bench Marks at interval of 200 m were established in order to facilitate for the investigation and execution of canal. Only from the middle of 1981 execution of canal works were started.

23.4 The excavation of Main Canal and distributories were taken up during the years, 1981, 1982, 1983 and till the middle of 1984. During this period lining had also been executed simultaneously for the main canal and distributories.

23.5 Localisation of the ayacut was taken up from 1984 and the construction of sluices and excavation of field bothies were taken up during the year 1984 and 1985.

23.6 The entire work in canal was expected to be completed by March, 1986 in all respects. While the works were in progress the accounts were also finalised and steps taken to record the completion reports and completion plans.

23.7 AYACUT AREA AND ALIGNMENT OF CANAL

Ayacut area of this project lies in Molaynur Venkatasamudram Menasi, Bothenatham, Alapuram, Sammanehalli villages on the Left Main Canal and Molayanur, Kolimakkanur, Adigarapatty, Dadampatty, Kavundampatty, Pudupatty, Pappireddipatti and Alamelupuram villages on the right main canal.

The hydraulic details of the canals are as follows:

Right Main Canal

Bed width	-	1.8 m (6 ft.)
Full supply depth	-	0.8 m (2.62 ft.)
Discharge	-	1.48 cumecs (52.3 cusecs)
Velocity	-	0.71 m/sec

Left Main Canal

Bed width	-	1.2 m (4 ft.)
Full supply depth	-	0.7 m (2.30 ft.)
Discharge	-	0.93 cumecs (32.5 cusecs)
Velocity	-	0.7 m/sec

Note : i) The size of the canals is progressively smaller as the tail end is reached.

ii) The RMC for a short length from its head has a greater capacity to accommodate the discharge for diversion to the river course below to feed the existing wet ayacut.

iii) In reaches where the required discharging is low the canal is constructed either as a masonry trough section (rectangular with concrete bed or as a concrete chute - trapezoidal)

Total extent that is benefitted is 3491 hectares (8550 acres).

The left side canal runs for a length of 19.397 km and it has six branches at appropriate places to feed an ayacut of 1639 hectares (4050 acres). The right side canal is excavated for a length of 12.741 km and it has two branches to feed an ayacut of 1852 hectares (4500 acres).

The left and right side main canal runs in Contour except for the tail end reaches of LMC and RMC where the alignment is in ridge.

23.8 MAIN AND BRANCH CANAL DESIGN - BASIC PRINCIPLE

Canal sections at various reaches of the project ayacuts were designed on the following basic principle:

The new ayacut to be served by the VRP canals is meant for dry crops. Therefore cultivation of wet crops has to be discouraged. It has been found in practice that this aim will be effectively served if intermittment rush supplies at 2.5" depth for every field are made on a 10 day turn. The ayacuts are divided (into zones) to achieve this purpose. There are two zones under each canal. The first zone in each main canal is given supply during the first five days. Then the sluices and distributories in this first reach are completely closed and the project water is taken to the second zone. At the end of first zone a regulator with shutters is constructed which will be kept closed during the period when the first zone lands are irrigated. This turn system is followed through out the crop season. When there are considerable rains in the ayacut area, the releases to the crops there are proportionately reduced.

The canal section in a given reach is determined with reference to the discharge it has to carry on the above considerations. Transmission seepage and evaporation losses at about 25% to 30% are added to the above requirement at field head. The gradient of the canal is arrived at depending upon the

limits of velocity which the formed sides and bed can withstand without erosion and excessive siltation. The following hydraulic formulae are applied (useful) for this purpose.

i) Manning's Formula V = $R^{2/3} S^{1/2}$

Where V = Velocity

R = Hydraulic mean depth (i.e. water section - wetted perimeter)

S = Slope of the channel

n = Manning regusity coefficient

ii) Chezy's Formula V = C

Where V = Velocity

m = hydraulic mean depth

i = slope and

C = Chezy's constant

Note : C may be taken as $1.486/n \times r^{1/16}$ where n is the roughness coefficient.

Chezy's C is also derived from Kutter's Formula which is

h here is Kutter's Rugosity coefficient.

Values of n for various surfaces are available in civil engineering hand books.

The levels of the canals are fixed with reference to the highest field which they have to irrigate. The alignment is fixed largely on economic considerations. But in unavoidable circumstances the canal may have to be taken in deep cutting and or on high embankments. But those sections are limited to the minimum requirement. Places of such exceptions met with in the case of Vaniar channels are mentioned in the later part of this chapter.

The alignment of the canal, its size (bed width and depth), the levels at all salient points along its run such as sluice, drops, cross drainages etc. to be generally approved by the Superintending Engineer. To details are shown in a compact drawing on a section sheet known as condensed L.S. Detailed executive instructions were issued for obtaining approval of condensed L.S. sanction of estimates and formation of the canal. These are working instructions circulated upto the levels of Junior/Assistant Engineers keeping in mind that the entire distribution system has to function effectively and its formation

and maintenance cost had to be low without sacrificing its sound technical standards. Some of these directions are given below.:

Alignment map has to be prepared showing original and revised alignment of canal.

Condensed L.S. of the revised L.s. has to be prepared to examine the feasibility of avoiding deep cutting and high embankment canal section design has to be finalised to fix the bed width and FDS of the canal for each reach. This will be checked in circle office and on receipt of Superintending Engineer's approval only, the estimates are to be prepared, got sanctioned and tenders called for and agency settled for execution of the work. Sufficient lengths of canal (say 10 m) on either side of cross masonry works may be left unexcavated until the type of cross masonry work is finally decided after the inspection of Superintending Engineer.

The canal at the tail end reaches where the discharge is considerabaly reduced can/should be formed using masonry trough instead of the usual lined canal to enable speedy execution as well as economic construction provided sufficient quantity of blasted stones are available at the site.

Two masonry wall 30 cms thick using random rubble in C.M. 1:4 using available blasted stones may be constructed over a bed of concrete 1:5:10 fifteen centimeters thick and plastered inside with C.M. 1:5 twenty millimeters thick. Suitable vent way may be allowed in between the walls to give the requisite discharge. This method is most suitable when the FSD (Full Supply Depth) is 45 cms and below.

When the trough has to be formed in cutting, sufficient care should be taken to see that the depth of cutting is not more than FSD + Free Board so that undue pressure due to earth retention can be avoided. Checking this aspect with reference to the site conditions is primarily important.

Whenever the blasted stones from the canal excavations is available in plenty the same can be economically used for lining the canal slopes in which case R R Masonry in C.M. 1:6, 20 cms thick and plastering with C.M. 1:4 all over inside can be adopted making best use of available blasted stone.

Another set of directions issued in a memo dated 03.05.82 which may be of interest to the reader is reproduced below:

Office of the Superintending Engineer, PWD Special Projects Circle, Krishnagiri.

No.1198/F.208.AE 1/date.03.05.82.

Sub : Formation of Jeep Track along Canal Banks - Adoption of 6 M width - reg.

Ref : This office Letter No.2746/812/F.62A/D4/dated.21.12.81.

The Chief Engineer (Irrigation) has instructed to provide 6m wide bank to the Canal instead of 3 m. hitherto being done so that the bank can be used to transport farm produce on development of ayacut. The Executive Engineers should be able to achieve this without any extra expenditure on bank formation or land acquisition. Following general guidelines are issued to fulfill the above objective.

1. The spoil bank on the uphill side (i.e. right bank RMC and left bank for LMC) may be formed to a height not more than 1.0 m, taking the toe right upto the line of acquisition.

2. Balance earth available from the canal cutting after the formation of spoil bank may be spread evenly over the other bank right upto the limit of acquisition to give the bank width of 6.0 m.

3. No earth should be borrowed to form the bank in the reach where the canal runs in full cutting.

4. If sufficient soil is not available for the jeep track it can be left as it is after spreading the available soil to the extent possible filling up the undulations,

5. The berms of canal at ground level may be limited to 1.0 m wide.

6. Side slopes of 1.5:1 may be adopted for the slopes of banks.

7. The plantation should be done at the edges of acquisition to avoid encroachment.

The achieve economy and speedy execution, the instruction has already been issued to take the canal alignment in normal depth of cutting (i.e. 1-1.5 m). A typical cross section of the canal with width of acquisition for a depth of cutting of 2.0 m is shown in the opposite page.

23.9 CASTING YARDS FOR PRECAST SLABS REQUIRED FOR LINING

The cost of the precast slabs was done at central place and the slabs were conveyed to the various sites through contractors' lorries. The aim was to ensure uniform quality control. In order to speed up the casting of slabs two casting yards (one at Pappireddipatty Colony camps and another at Dam site right flank) were constructed. Two big wells were already in existence in these places. Improvements to these wells were carried out in order to ensure contemplated supply. Pumpsets were erected and pipeline laid to supply water to the casting yard. For curing purpose one tank of size 24 m x 12 m x 0.8 m was constructed at Pappireddipatti. Another tank of the same dimensions was got ready at Dam site yard too.

Casting Equipment

In the year 1981 the machinery such as concrete mixer, table vibrator and other materials such as base plate and moulds were purchased. Two

new concrete mixers were purchased from PWD work shop and stores Madras. The base plates and moulds were purchased from TANSI Workshop. One Diesel concrete mixer, one diesel table vibrator and 900 nos. of base plates and 150 nos. of moulds were procured for the casting yard at Pappireddipatti.

Similarly one concrete mixture and one table vibrator 969 nos. of base plates and 182 nos. of moulds were procured for the casting yard at dam site. One store to store the cement and other materials and one shed to erect the table vibrator were constructed at Dam site and Pappireddipatti. One sub-division was entrusted with the casting yard of the slabs, in order to ensure proper quality. Each casting was under the charge of one Junior Engineer so that the casting was done under direct supervision and control of the Departmental Officers.

Casting Procedures

The materials required for the concrete was measured in boxes and mixing done by concrete mixers; proper care had been taken to ensure the use of adequate water cement ratio. Necessary care was taken to use only good quality sand. After mixing the concrete was filled in the mould with proper hand compaction and mould was used as an unit. This unit with concrete filled in the mould wa placed on the table vibrator. The vibration of the table vibrator was so adjusted to get proper compaction of the concrete. After proper compaction was achieved the unit containing the mould and base plate was taken from the vibrator. The sides of the mould were removed and any damage to the edges was set right by manual labour (masons) using cement mortar 1:2 and trowelling hard and smooth. After allowing the slab to remain in the base mould for a day, the slabs were transferred for curing under water in the curing tank where water was kept stored to the full level to ensure that the entire portion of the slab is well immersed in water. In this immersed condition the slabs were kept for 21 days to allow for proper curing afterwards they were stored in stacks. The stacks were arranged in longitudinal slanting condition. No stack was allowed one over the other. This was ordered to allow for easy handling and to avoid any damage.

Daily casting of the slabs was in the order of 1000 slabs at dam site and another 1000 slabs at Pappireddipatti. These slabs were loaded into the lorries carefully by means of manual labours and conveyed to the site and used in the work.

The slab casting works were going on during the years 1981, 1982 and 1983 and in all a total of 3,01,322 slabs had been cast at dam site casting yard and 2,89,656 slabs were cast at Pappireddipatty.

23.10 SPCIFICATIONS FOR LINING

The Vaniar canal was lined with cement concrete 1:2:4 precast slab of size 50 x 30 x 6 cm along the sides. The bottom was of CC 1:3:6 cast in situ for 7.5 cm thick. Necessary model sections were built with R.R. Masonry in CM 1:8 at 13.5 m intervals and the expansion joints were provided at these

points. Wherever blank cotton soil was met with necessary gravel backing was provided and the lining slabs were set over this formed base. Generally 1:1 slope was followed for lining in all areas and 1.5:1 slope was adopted in the entire black cotton soil areas.

23.11 MODE OF EXECUTION

After the excavation of the canal to the required slope and size the sections were trimmed. Model sections with Random Rubble masonry of C.M. 1:8 were to be constructed at an interval of 12.5 m. Precast slab were conveyed to the site and each slab set with cement mortar 1:4 to serve as binding material. The bottom slab was seated on a lug concrete of size 10 cm x 10 cm of 1:3:6.

This method was later modified as described below:

The practice of construction of binder wall with R R masonry was dispensed with after 9/82. Instead precast slab of 50 x 15 x 6 cm in CC 1:2:4 may be used, by placing the slab on edge along the perimeter of canal section below he continuous joints to be provided across the section at 12 m intervals along the canal. (vide - VI joints in Circular No.1276/F.208/AE1/dated.10.05.82)

The weep holes to be provided in the lining can be obtained by leving a hole in the precast slab itself during casting the same by means of a bit of pipe or a wooden plug. Care must be taken to see that the hole thus made during casting is in a slanting position so that a horizontal weep hole is obtainable on fixing the precast slab in position.

During inspection by the Chief Engineer (Irrigation) the Chief Engineer (Irrigation) has instructed to continue the bed cast in-situ concrete, to some distance along the slope of the canal at the bottom with a fine curve at the bottom corners. This may be ensured by extending the bed concrete by 30 cm. or to the extent required, so as to have the number of full slabs over it up to the FSL + free board on either side over which the precast slabs can be supported.

After the slab were set the berm was provided with either precast slab set at right angle to the slab already fixed on the slopes or freshly mixed concrete in proportion 1:2:4 laid, tamped and finished smooth at site.

Then the cement concrete mix 1:3:6 has been laid for 7.5 cm thick for the bed. VPG concrete mixer of capacity 7/5 cft. was employed to mix the concrete. Water required for the mixing of concrete and curing was drawn from the private wells situated near the canal alignments.

The following circular was issued by Superintending Engineer, PWD, Special Project Circle, Krishnagiri explaining the arrangements of joints in canal lining with precast slabs.

Circular Memo No.1276/F208/AE/Date/.10.05.82.

The joints in the concrete lining in canals should be as per the instructions issued below. The sketh opposite page shall be referred to. In addition to the weep holes provided, butt joints in the concrete slab without cement mortar should be provided in the sides as indicated in the sketch.

V1 = Full joint in bed and sides with mastc pad 1/2" thick

V2 = Full joint (construction joint) butt joint with mortar

V3 = Butt joint in in-situ concrete for bed

J1 = Butt joint in the slabs one for every 6 slabs. Slabs touching each other without gap and without mortar. This will be provided in the two courses of slabs one just above the bottom course and in one just above this second course. The joints will be staggered in the two courses.

Sd/-
Superintending Engineer, PWD
Special Project Circle, Krishnagiri

23.12 CUT AND COVER

In the Left Main Canal the reach between LS 1075 m to 1740 m was in heavy cutting, the depth of which range from 9 m - 11 m. It was initially proposed to cut the canal in this portion and lay 1.4 MRC hume pipe with earth filling over the pipes from bottom to ground level.

The proposed cut and cover was rooted on the assumption that the sides slip due to such high depth of cutting. While the excavation at this reach was in an advanced stage the Chief Engineer (Irrigation) inspected the work. It was pointed out by the Chief Engineer that the sides of the excavation are not very loose and the cut and cover need not be executed for the entire reach. Instructions were also given to lay 1.4 m RC hume pipe and cover the canal only in the following points:

i) Tank crossing
ii) Drainage crossing
iii) Road crossing

According the cut and cover has been executed in the reaches mentioned below.

i) L.S.1185 to 1225 m to serve as road crossing
ii) L.S.1320 to 1370 to serve at cut and cover as the sides as of the canal was very loose.
iii) L.S.1425 to 1475 to serve as drainage crossing
iv) L.S.1600 to 1740 to serve as Tank crossing

23.13 MODE OF EXCAVATION OF CUT AND COVER

1.4 m diameter RC hume pipes were procured from M/s Ralley Industries, Pudikottai who produce the same by employing the specially prepared mould. These pipes were conveyed by them through their lorry and supplied at site.

These pipes weighing roughly 1.5 M.T. were lowered into the canal by utilising derric post chair pully block G.I. pipes and Manila ropes

Through tender the work was entrusted to Zarang Labour these Zarang Labours being specially trained for such purposes and they were able to execute the work without much difficulty. These pipes were fixed in position and certain amount of sand filling underneath the pipes and by the sides of the pipes was done to serve as cushioning material. Cement slurry and jute coir ropes were utilised for packing the gap between the pipe and collar. Near the collar joint cement mortar 1:2 has been applied in a triangular shape to serve for additional bondage. For half the height of the pipe, piers were constructed in cement mortar 1:3:6 on both sides to fix the pipes in an erect position. Piers of the same type were constructed at the entry and exit points also. Random Rubble Masonry was constructed for a height of about 2.5 m to retain the filled earth at exit points. After these works are completed the portion above the pipes were filled with selected soils with proper consolidation. The sides of the filling were protected with rough stone dry packing to event slippage.

23.14 CONSTRUCTION OF CROSS MASONRY WORKS IN VANIAR CANAL SYSTEM

Following are the various cross masonry works constructed in Vaniar Canal system.

1. Side walls	2. Chutes
3. Aqueduct	4. Under Tunnel
5. Super Passage	6. Well Drop
7. Canal Syphon	8. Culvert

Some aspects of design concepts of work is explained in the following paras.

23.15 CONSTRUCTION OF SIDE WALLS

In respect of Vaniar Canals the terrain was such that there was earth cover for a depth of about 0.3 m to 0.6 m and the surrounding areas are cultivable lands. Due to the cost of the formation of embankment in canal was found to be very prohibitive.

On economy consideration side walls with R.R. masonry in C.M. 1:4 has been constructed over cement concrete 1:5:10 for 300 mm thick.

The design of the side wall are based on the Superintending Engineer, Project Circle, Krishnagiri Memo No.1624/F208/AE(I)dated.10.08.81. vide Drawing No.2FE/SPL/S1.82.

Bed concrete has been proposed with concrete 1:3:6 for 7.5 cm thick and finishing the top with cement 14.4 Kg/M³ of concrete.

Top of masonry has been finished with platering of 1:4 20 mm thick bed slopes of the normal lining maintained at side wall portions also.

23.16 CONSTRUCTION OF CHUTES

In some areas the topography of the country was very steep. By the adoption of the normal canal slope series of drops were found necessary. Superintending Engineer has instructed that in such locations chutes may be constructed. Based on this chutes were constructed in certain locations of the right and left canals where the ground along the alignment is steeply sloping.

The chutes are made of Rahdom Rubble masonry in cement mortar 1:6 for the bed and sides slopes. The masonry walls are plastered with cement mortar 1:4 twenty millimetres thick.

At the end of the chute a stilling basin is provided to reduce the critical flow to normal flow conditions.

23.17. CONSTRUCTION OF AQUEDUCT

To calculate the flood discharge the precipitation method was followed 24" rainfall in 24 hours duration had been assumed. As per the Chief Engineer's instruction twice the discharge has been taken for designing the vent way.

Scour depth has been calculated by using the formula R = 1.35 (Q/t)1/3 and the structure taken below the depth to be calculated. The foundation concrete proposed with cement concrete 1:5:10 for 0.40 m depth.

Random Rubble masonry with cement mortar 1:4 has been proposed for abutment and wings.

The deck slab and side walls were proposed with reinforced cement concrete 1:1 1/2:3 using 20 mm jelly. Concrete mixers were employed for the laying of RCC.

For the bed and sides of the drain rough stone packing apron and revetment provided.

23.18 CONSTRUCTION OF UNDER TUNNEL

Under Tunnels were constructed in the Vaniar Canl system and the specifications of each component are as follows:

Foundation	:	**In cement concrete 1:5:10 for 30 cm thick for abutment and 15 cm thick for transition.**
Superstructure	:	**Random Rubble masonry in cement mortar 1:5 for abutment canal side walls and trnsitions.**
R.C. Slab	:	**Proposed with R.C.C. 1:2:4**
Plastering	:	**Propoed with C.M. 1:4 Twenty millimetre thick for top of side walls transitions.**
Rough stone Packing	:	**Provided for the upstream and downstream side of the drain.**

23.19 CONSTRUCTION OF SUPER PASSAGE

To drain the super passage maximum flood discharge was calculated on the basis of precipitation method. As per the Chief Engineer's instruction 50 percent extra has been added to this and vent way decided accordingly.

Foundation proposed with cement concerte 1:5:10 using 40 mm jelly for 30 cm thickness.

For abutment wings and returns R.R. masonry in cement mortar 1:5 was proposed. Top side of the Parapet wings returns are plastered with CM 1:4 twenty millimetres thick.

RCC 1:2:4 slab proposed with suitable reinforcement. Wearing coat in cement concrete 1:3:6 using 12 mm stone jelly proposed for 75 mm thick.

Rough stone dry packing for the upstream and downstream sides provided.

23.20 CONSTRUCTION OF WELL DROP

In Vaniar Canl system well drops are proposed with R.R. masonry for 45 cm. The foundation was formed with cement concrete 1:5:10 using 40 mm gauge jelly for 30 cm thick. The front notch designed as trapezoidal and tie bear notch designed as rectangular.Top and sides of well and transition plastered with cement mortar 1:4 twenty millimetres thick. At the botom of well wearing coat with cement concrete 1:3:6 to 7.5 cm thick provided. A water cushion of 30 cm depth provided with the well lip stone and lintal proposed with RCC 1:2:4.

23.21 CONSTRUCTION OF CANAL SYPHON

Maxmimum flood discharge was calculated for the drainage course after assuming the C value as 1500 for the hill area and 1000 for plains. Velocity of flood water assumed as 3 ft./second and based on this the waterway was designed.

For designing the syphon barrel the velocity has been taken as 1.5 times the designed velocity of canal.

Following are the other technical aspects of this component

Foundation : Provided with 40 cm thick cement concrete 1:5:10 using 40mm jelly.

Well	:	On both ends of the barrel the syphon well is constructed with R.R. masonry in C.M. 1:5 for thickness varying from 0.75 m to 0.45 m.
Barrel	:	RCC box type barrel with M-20 concrete was proposed 2" cover was adopted. The thickness provided for top and botom of the box necessary anchorge provided between the barrel and foundation by means of anchor rods. The inner sides of barrel plastered with C.M. 1:3 Ten millimetres thick.

Rough stone dry packing provided for jeep track for a short distance on either side.

23.22 CONSTRUCTION OF CULVERTS

Whenever the canal crosses the main road or recognised cart track culverts were proposed for crossing the Highway and the road. The specifications are as per Highways standards. In such cases approval has been obtained for the design and drawing from the Highways Department.

Foundation was provided with cement concrete 1:4:8 and using 40 mm jelly for 40 cm height.

Abutment provided with R.R. masonry in C.M. 1:3. The bed block and deck slab will be with RCC 1:2:4 using 20 mm size jelly.

Wearing coat provided with 1:1.5:3 using 20 mm size jelly.

Parapet wall will be with R.R. masonry in C.M. 1:5. Necessary transitions constructed with R.R. masonry on the upstream and downstream sides.

23.23 GROUPING OF AYACUT

In the main canal and distributaries, sluices were constructed at appropriate places. The ayacut area under each sluice is divided into 25 acres block and each block is proposed to be supplied through pipe points. Field bothies are excavated at Government cost to reach the 25 acre block. In side these blocks the field bothies have to be excavated by the beneficiaries themselves. Field bothies are only earthen channels and the bed slope followed is generally 1 in 300 for all soils (except black cotton soil) and 1 in 500 for black

cotton soil core wall type drops are constructed with R.R. masonry at the required places. Rough stone dry packing provided on the upstream and downstream side of the drops.

ACTUAL EXPENSES FOR THE CANAL SYTEM

The actual expenditure incurred and the corresponding scheme provisions inthe case of Vaniard Project canals are as follows:

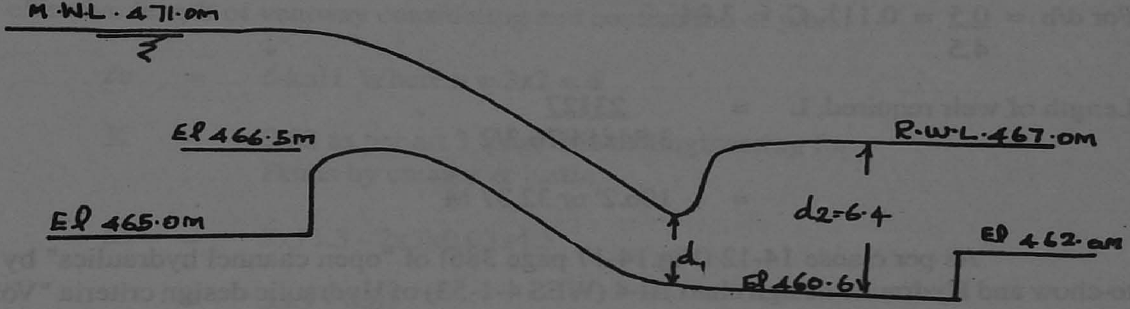
Sl. No.	Items	Scheme Provision (Rs.)	Actual Expenditure (Rs.)
1.	Preliminaries	90,000	5,37,953
2.	Earth work	15,70,000	59,35,580
3.	Lands	13,50,000	19,43,386
4.	Works including Lining	34,90,800	1,17,80,434
5.	C.D. works	10,60,000	21,97,231

ANNEXURE
VANIAR RESERVOIR PROJECT

DESIGN OF SURPLUS REGULATOR

Hydraulic Particulars

Maximum flood discharge	=	654.9 cumecs (23127 c/s)
Top of roadway	=	473.10M
M.W.L.	=	Ed 471.0M
R.W.L.	=	El 467.0M (as furnished by S.E.in Lr.No.28M/79/AE(2), dt.4.12.79.
Weir crest	=	El 466.5M (as furnished by S.E. Project Circle in the above reference).



The surplus regulator is designed on permeable foundation since the field staff has reported that no rock is available at reasonable depth at the proposed site of the regulator. Since the difference between the crest and M.W.L. is only 4.5 M (471.0-466.5-4.5M) a regulator with radial gates is proposed.

Design of Vents:

The ventuary is designed by the following three methods:

a) For the submerged weir, the tail water above the weir crest will not influence the discharge till the tail water above the weir crestis about 2/3 the upstream depth above the weir crest as per the findings of Irrigation Research Station, Poondi, i.e. the submerged weir actsin such the same way as a weir with clear overfall condition with the tail water depth above the crest of weir, less than 2/3 the upstream depth above crest.

The rear water depth above the crest = El 467.0 - El 466.5 = 0.5 M

which is less than 2/3 the front water depth above the crest. i.e. less than 2/3 x 4.5 = 3.0M

Hence coefficient of discharge for clear over fall condition (i.e. 3.97 is adopted)

Q = 654.9 cumecs (23127 c/s)

H = 4.5M (14.76')

Q = CLH 3/2

For an ogee profile, length required, L $= \frac{Q}{CH^{3/2}}$

$= \frac{23127}{3.9 \times 14.76^{3/2}}$

$= \frac{23127}{3.9 \times 56.706}$

= 104.6'or 31.87M

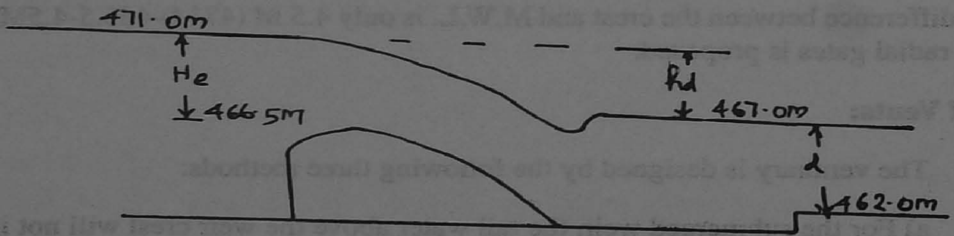
b) As per the Chief Engineer (Irrigation)'s circular Memo No.R1/1918/64-40, dt.18.10.67, the coefficient of discharge for submerged condition is calculated from the graph.

For d/h = $\frac{0.5}{4.5}$ = 0.111, C = 3.84

Length of weir required, L $= \frac{23127}{3.84 \times 14.76^{3/2}}$

= 106.2' or 32.37 M

As per clause 14-12 (Fig.14-17 page 386) of "open channel hydraulics" by ven-te-chow and Hydraulic design chart III-4 (WES 4-1-53) of Hydraulic design criteria "Vol I by corps of Engineers U.S.A. the percentage of reduction in the discharge coefficient for sub-merged overflow spillway is calculated as follows:



Head over crest, He = 471.0 - 466.5 = 4.5 M

Level difference between U/s & D/s water level } hd = 471.0 - 467.0 = 4.0 M

Rear water depth, d = 467.0 - 462.0 = 5.0M

$\frac{hd}{He} = \frac{4}{4.5}$ = 0.888

$\frac{hd+d}{He}$ = $\frac{4+5}{4.5}$ = 2.0

From the chart reduction in coefficient of discharge = 0.4%

∴ Coefficient of discharge = $3.9 - \frac{0.4}{100} \times 3.0$

= 3.9 - 0.0156 = 3.88

Length of weir required, L = $\frac{23127}{3.88 \times 14.76^{3/2}}$

= 105.11 or 32.04 M

Taking the maximum value for L (i.e. 32.37 M)

3 vents of size 11.3 M x 4.5 M is proposed for the bed regulator.

The effective length of ventway considering end contraction of piers,

le = l-knH Where n = 3x2 = 6

K = 0.03 as per art 3, page 366 of Engineering for Dams by creager & justin

le = 3x11.3 - 2x3x0.03x4.5

= 33.9 - 0.81

= 33.09 M against the required length of 32.37M

Discharging capacity of the proposed vents, Q = $3.84 \times 14.76^{3/2} \times 33.09 \times 3.28$

= 23633.65 c/s (669.22 cumecs)

Energy dissipation arrangement :

Intensity of discharge, q = $\frac{669.22}{3 \times 11.3}$ = 19.74 cumecs

Maximum Water level u/s = El 471.0M

R.W.L. = El 467.0M

Head Loss = 471.0 - 467.0

= 4.0M

Referring to Table II of CBIP Publication No.4 for the Values of q = 19.74 cumecs and HL = 4.0M, the value of total energy,

Ef2 is calculated as follows:

For q = 18 & HL = 4.0M, Ef2 = 6.85

For q = 20 & HL = 4.0M, Ef2 = 7.26

By interpolating for q = 19.74 & HL = 4.0M

$$Ef2 = 6.85 + \frac{(7.26 - 6.85)}{2} \times 1.74$$

$$= 6.85 + 0.357$$

$$= 7.207$$

From Plate III of CBIP publication 4, for a depth of 5.0 M (Rear water level - Rear floor level) and q = 19.74

Energy of flow, Ef = 5.807

Depth of stilling basin = Ef2 - Ef = 7.207 - 5.807

= 1.4M

Stilling basin floor level = Rear floor level - depth of stilling basin

= 462.0 - 1.4 = 460.6 M

Depth after jump, d_2 = Rear water depth + stilling basin depth

= 5.0 + 1.4 = 6.4 M

Velocity after jump, $V_2 = \frac{q}{d_2} = \frac{19.74}{6.4} = 3.08$M/sec.

From Plate XI of CBIP publication 4, for $d_2 = 6.4$ and $V_2 = 3.08$M/sec. d_1 works out to 1.510M.

Length of stilling basin = $5(d_2 - d_1) = 5(6.4 - 1.510)$

= 24.45 M

or Say 25.0M

BUCKET :

As per graph (Fig12) is page 373, art 4 of "Engineering for Dams" by creager & justion V of II, For weir height of 5.9 M (19.35') and head over crest 4.5M (14.76') radius of bucket = 20'(6.1M)

Provide baffle blocks of size 1.8M x 0.9M x 0.6M in two rows in a stagged manner with a clear distance of 1.80M is both the directions. The centre of two rows, 8.0M

away from the end of D/S apron has been proposed tentatively and final arrangements are to be decided after model studies at I.H.H. Poondi.

GATES FOR THE SURPLUS REGULATOR :

Radial gates here been proposed instead of providing vertical lift gates as requested by the S.E. Spl. Project circle Krishnagiri in Lr.No.28M/79/AE(2)/dt.14.12.79. Is 4623-1967 stipulates the following criteria for fixing the radius of the gate and the location of the trunnions:

ART 5.2.1:

"The trunnions of the gate shall be so located that under conditions of maximum discharge over the spillway barrage, they shall remain at least 1.5 metres clear of the water profile with gates having the trunnions on the upstream side, the trunnions have to remain submerged in water, but suitable precautions shall be taken to prevent corrosion of the trunnion parts under such conditions".

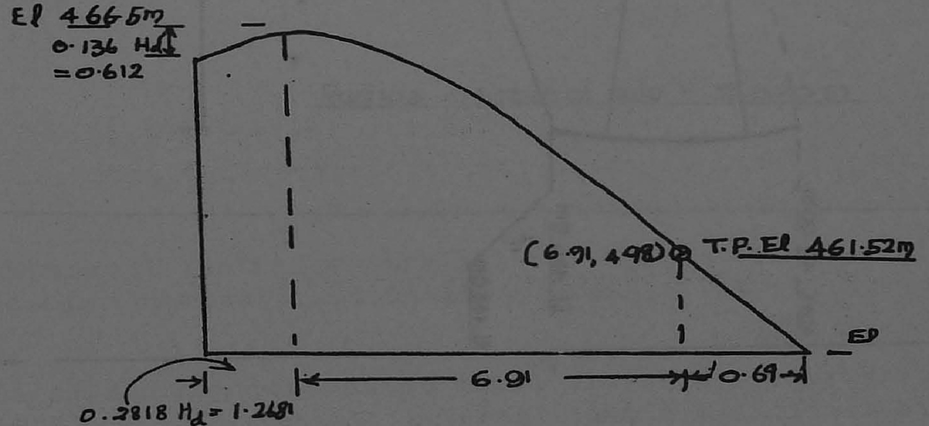
Art 5.3:

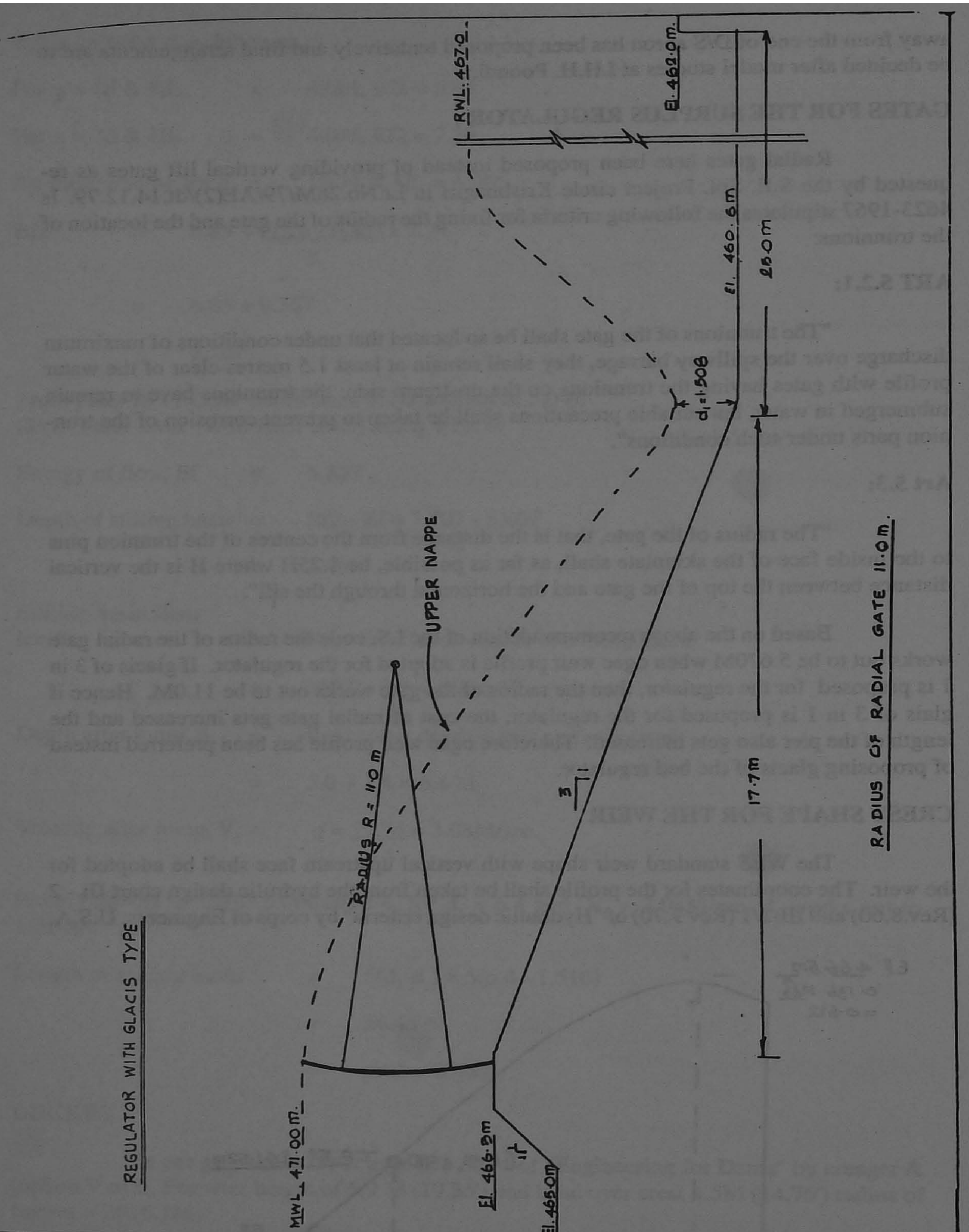
"The radius of the gate, that is the distance from the centres of the trunnion pins to the inside face of the skinplate shall, as far as possible, be 1.25H where H is the vertical distance between the top of the gate and the horizontal through the sill".

Based on the above recommendation of the I.S. code the radius of the radial gate works out to be 5.670M when ogee weir profile is adopted for the regulator. If glacis of 3 in 1 is proposed for the regulator, then the radius of the gate works out to be 11.0M. Hence if glais of 3 in 1 is proposed for the regulator, the cost of radial gate gets increased and the length of the pier also gets increased. Therefore ogee weir profile has been preferred instead of proposing glacis of the bed regulator.

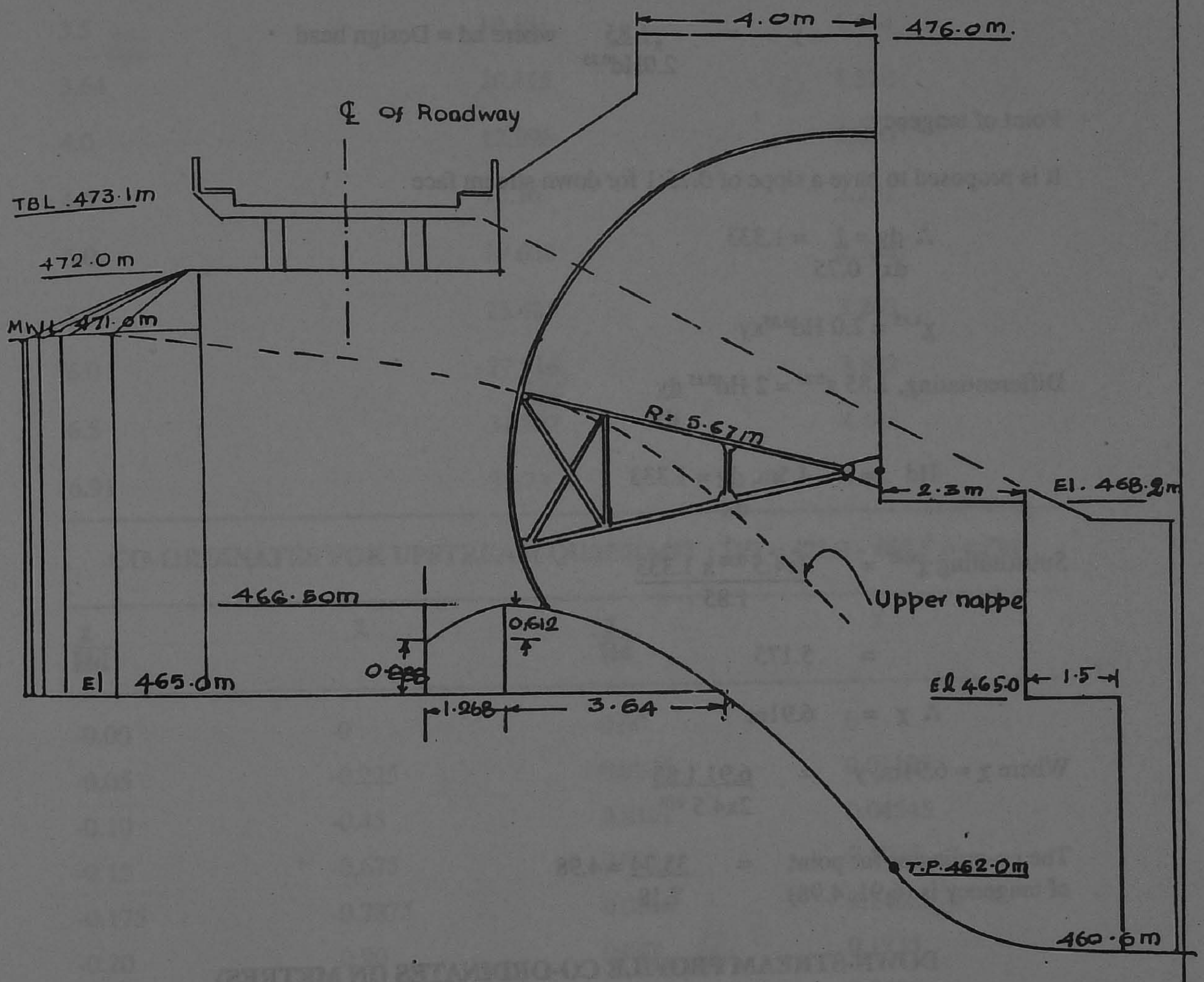
CREST SHAPE FOR THE WEIR

The WES standard weir shape with vertical upstream face shall be adopted for the weir. The coordinates for the profile shall be taken from the hydrulic design chart III - 2 (Rev.8.60) and III-2/1 (Rev 9.70) of "Hydraulic design criteria" by corps of Engineers, U.S.A.




REGULATOR WITH GLACIS TYPE
MWL 471.00 m
El. 466.2 m
El. 465.0 m
RADIUS R = 11.0 m
UPPER NAPPE
3
1
d1 = 1.508
El. 460.6 m
25.0 m
17.7 m
RWL 467.0
El. 462.0 m
RADIUS OF RADIAL GATE 11.0 m

WEIR WITH WES. PROFILE



Radius of radial gate = 5.670 m

DOWNSTREAM CO-ORDINATES:

Equation of curve $\quad x^{1.85} = 2.0\ 1{+}d^{0.85}.y$

$$y = \frac{x^{1.85}}{2.0Hd^{0.85}}$$ where hd = Design head

Point of tangency:

It is proposed to have a slope of 0.75:1 for down stream face

$$\therefore \frac{dy}{dx} = \frac{1}{0.75} = 1.333$$

$$\chi^{1.85} = 2.0\ Hd^{0.85}xy$$

Differentiating, $1.85\ x^{0.85} = 2\ Hd^{0.85}\frac{dy}{dx}$

$$Hd = 4.5m, \frac{dy}{dx} = 1.333$$

Substituting $\chi^{0.85} = \dfrac{2x4.5^{\ 0.85}x\ 1.333}{1.85}$

$$= 5.175$$

$$\therefore \chi = 6.91m$$

Where $\chi = 6.91m$, $y = \dfrac{6.91\ 1.85}{2x4.5^{\ 0.85}}$

The co-ordinates for point of tangency is (6.91, 4.98) $= \dfrac{35.74}{7.18} = 4.98$

DOWN-STREAM PROFILE CO-ORDINATES (IN METRES)

χ	$\chi^{1.85}$	$y = \dfrac{\chi^{1.85}}{2xHd^{0.85}}$
0.25	0.0769	0.0107
0.50	0.2774	0.0386
1.0	1.0	0.139
1.5	2.117	0.295
2.0	3.605	0.502
2.5	5.4474	0.759

2.83	6.85	0.954
3.0	7.633	1.063
3.5	10.151	1.414
3.64	10.915	1.520
4.0	12.996	1.810
4.5	16.16	2.251
5.0	19.638	2.735
5.5	23.425	3.263
6.0	27.516	3.832
6.5	31.907	4.444
6.91	35.73	4.98

CO-ORDINATES FOR UPSTREAM QUADRANT : HD = 471.0 - 466.5 = 4.5M

$\frac{\chi}{Hd}$	χ	$\frac{y}{Hd}$	y
-0.00	-0	0.00	0
-0.05	-0.225	0.0025	0.01125
-0.10	-0.45	0.0101	0.04545
-0.15	-0.675	0.023	0.1035
-0.175	-0.7875	0.0316	0.1422
-0.20	-0.90	0.043	0.1935
-0.22	-0.99	0.0553	0.2489
-0.24	-1.08	0.0714	0.3213
-0.26	-1.17	0.0926	0.4167
-0.276	-1.242	0.1153	0.5189
-0.278	-1.251	0.1190	0.5355
-0.2818	-1.2681	0.136	0.612

CO-ORDINATES FOR UPPER NAPPE PROFILE ALONG THE CENTRE LINE OF PIER BAY:

FO $\frac{H}{Hd} = 1.0$

$\frac{\chi}{Hd}$	χ	$\frac{y}{Hd}$	y
-1	-4.5	-0.941	-4.2345
-0.8	-3.6	-0.932	-4.194
-0.6	-2.7	-0.913	-4.1085
-0.4	-1.8	-0.890	-4.005
-0.2	-0.9	-0.855	-3.8475
0.0	0.0	-0.805	-3.6225
0.2	0.9	-0.735	-3.3075
0.4	1.8	-0.647	-2.9115
0.6	2.7	-0.539	-2.4255
0.8	3.6	-0.389	-1.7505
1.0	4.5	-0.202	-0.909
1.2	5.4	-0.015	0.0675

CO-ORDINATES FOR UPPER NAPPE PROFILE ALONG THE PIERS:

FO $\frac{H}{Hd} = 1.0$

$\frac{\chi}{Hd}$	χ	$\frac{y}{Hd}$	y
-1.0	-4.5	-0.95	4.275
-0.8	-3.6	-0.94	4.23
-0.6	-2.7	-0.929	4.181
-0.4	-1.8	-0.930	4.185
-0.2	-0.9	-0.925	4.163
0.0	0.0	-0.779	3.51
0.2	0.9	-0.651	2.93
0.4	1.8	-0.545	2.453
0.6	2.7	-0.425	1.913
0.8	3.6	-0.285	1.283
1.0	4.5	-0.121	0.545
1.2	5.4	0.067	0.302
1.4	6.3	0.286	1.287
1.6	7.2	0.521	2.345
1.8	8.1	0.779	3.506

DESIGN OF CUT OFF WALLS ON THE UPSTREAM AND DOWN STREAM SIDES:

i - cut of walls on the upstream side:

a) As per page 222 of theory and design of Irrigation structures, Vol.I by R.S. Varshney.

depth of U/S cut off $= \frac{d_1}{3} + 0.6$

(where d_1 = depth of water U/S)

$= \frac{(471.0 - 465.0)}{3} + 0.6$

$= 2.0 + 0.6 = 2.6m$

Bottom level of cut off wall = 465.0 - 2.6 = 462.4M

b) Depth of U/s cut off wall from scour depth consideration:
Design discharage, Q = 669.22 cumecs
Concentration factor = 20% (vide page 175 of CBIP Pub.12)

Taking into account the concentration factor

$Q = 669.22 + \frac{20}{100} \times 669.22 = 803.064.$

As per clause 9.2 of I.S. 6966 - 1973 minimum
stable width, P $= 4.83.\ Q^{1/2}$

$= 4.83 \sqrt{803.064} = 136.87$ m

Assuming thickness of pier as 3.0m, overall length of regulator = 11.3x3+2x3 = 33.9+6.00 = 39.9 Loosiners factor $= \frac{39.9}{136.87} = 0.29 < 1$

Hence scour depth, $R = 1.35 \left(\frac{q^2}{f}\right) 1/3$

If looseners factor is more than 1, scour depth, $R = 0.475 \left(\frac{Q}{f}\right) 1/3$ (vide clause 17.1 of I.S. 6966 - 1973)

Discharge per M. run, q = 19.74 cumecs, Taking into account the concentration factor,

$q \doteq 19.74 \times 1.2 = 23.7$ cumecs

Scour depth R $= 1.35 \left(\frac{q2}{f}\right) 1/3$ where q = 23.7 cumecs

f = silt factor = 1.5 for course sand

$R = 1.35 \left(\frac{23.7^2}{1.5}\right) 1/3 = 9.73m$

Maximum scour depth on u/s= 1R = 9.73m

Level upto which scour can occur on u/s = 471.0 - 9.73 = 461.27m

Hence u/s. cut off wall bottom level has been kept at EL 461.0m

ii) Cut off walls on the downstream side:

a) As per page 222 of Theory and Design of Irrigation structures, Vol.I by R.S. Varshney,

Depth of D/S cut off $= \frac{d_3}{2} + 0.6$

(where d_3 = water depth D/s)

$= \frac{(467.0-462.0)}{2}+0.6 = 3.1$

Bottom level of D/s cut off wall = 462.0 - 3.1 = 458.9 M

b) Depth of D/s cut off wall from scour depth consideration

Max.scour depth on D/s side = 1.25 x R

(vide art 15.1,I.S.6966-1973)

= 1.25x9.73 = 12.16m

Level upto which scour can occur on D/s side

467.0-12.16 = 454.84m

Hence D/s cut off wall bottom level has been kept at 454.0M

The cut off walls have been proposed with their base width of 1.0M at their bottom and both the sides tapering in 1:8.

DESIGN OF SOLID UPRON THICKNESS:

- Khosla's theory is adopted for the design of apron thickness. As per CBIP publication 12 (page 114) factors of safety to critical values of exit gradients are as follows:

Shingle	4	to	5
Coarse sand	5	to	6
Fine sand	6	to	7

As per page 129 of CBIP Pub.12. to safe guard against undermining, the exit gradient must not be allowed to exceed a certain limit generally 1/5 to 1/7.

As per the bore hole details furnished, the soil available is Kankar and the exit gradient adopted for design purpose is 1/5.

The floor will be subjected to maximum uplift pressure when water is upto MWL in the u/s side and no water in the D/S side.

Maximum statichead, H = 471.0 - 460.6 = 10.4 M

$1/\pi \sqrt{\lambda}$ = GE d/H where d = Depth of D/s cut off.

= 462.0 - 454 = 8.0 M

$\therefore 1/\pi \sqrt{\lambda}$ = 1/5 x 8/10.4 = 0.1538

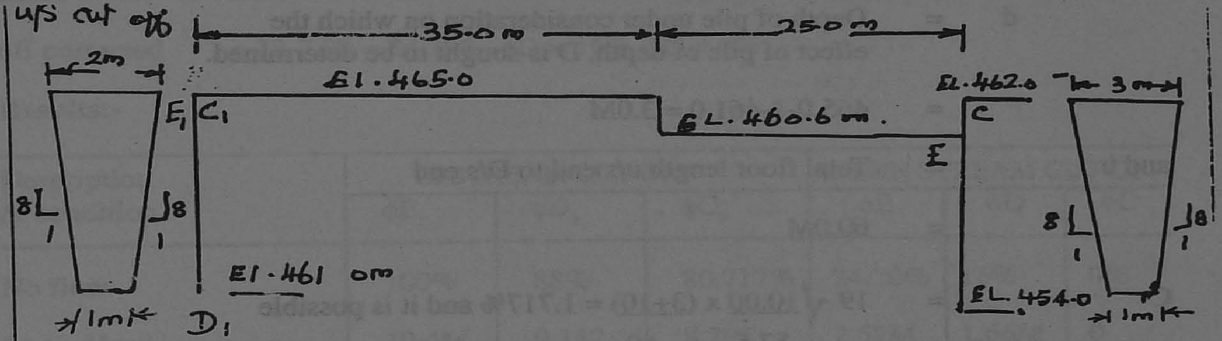
From Khosla's exit gradient curves, plate VII/5 of CBIP pub.12.

For $1/\pi \sqrt{\lambda}$ = 0.1538, α = 7.5

where b = total length of floor

d = depth of D/s cut off

$\therefore$ b = αd = 7.5 x 8 = 60.0M



i) Upstream pile - ϕE_1, ϕD_1, ϕC_1

d = Depth of u/s pile under consideration = 4.0M

b = Total length of floor u/s end to D/s end = 60.0 m

$1/\alpha$ = $\frac{d}{b} = \frac{4}{60} = 0.06667$

From plate VII/6, for $1/\alpha = 0.06667$, $\phi D_1 = 12$, $\phi E = 24$

$\phi E_1 = 100\%$; $\phi D_1 = 100 - \phi D_1 = 100 - 12 = 88\%$

$\phi C_1 = 100 - E = 100 - 24 = 76\%$

a) Correction for thickness of floor for ϕC_1:

Assume U/s floor thickness of 1.0M near cut off for a cut off wall depth of 4m, correction = 88-76 = 12%

For 1m thickness, correction = 12/4 x 1 = 3 and it is positive.

b) Correction for interference of pile for ϕC_1 by D/S pile:

$C = 19 \times \sqrt{\frac{D}{b^1}} \times \left(\frac{d+D}{b}\right)$, as per page 133 of CBIP publication 12.

Where C = correction to be applied as % of head

b^1 = distance between two concerned piles (centre to centre of piles)

$= 60 - \frac{2.0}{2} - \frac{3}{2} = 60-1-1.5 = 57.5M$

D = Depth of pile line, the interference of which has to be determined on the neighbouring pile of depth `d'

= (465.0-1) - 454 = 10.0M

d = Depth of pile under consideration on which the effect of pile of depth, D is sought to be determined.

= 465.0-1-461.0 = 3.0M

and b = Total floor length u/s end to D/s end

= 60.0M

C = $19\sqrt{\frac{10.00}{57.5}} \times \left(\frac{3+10}{60}\right) = 1.717\%$ and it is possible

∴ ϕE_1 = 100% ; $\phi D_1 = 88\%$; ϕC_1 corrected = 76+3+1.717 = 80.717%

ii) Down stream pile - ϕE_1. ϕD_1. ϕC_1 :

d = Depth of D/s pile under consideration

= 462.0 - 454.0 = 8.0M

b = Total length of floor u/s end to D/s end = 60.0M

$1/\alpha$ = b/d = 8/60 = 0.13334

From plate VII/6, for $1/\alpha = 0.13334$

$\phi D = 16\%$; $\phi E = 32\%$; $\phi C = 0\%$

a) Correction for thickness of floor for ϕE:

Assume a floor thickness of 2.5M near D/s pile for a pile of 8 M depth, correction = 32-16 = 16% For (1.4+2.5) = 3.9 M depth, correction = $\frac{16}{8} \times 3.9 = 7.80\%$

and the correction is -ve

b) Interference correction for ϕE by u/s pile:

% of correction, C $= 19 \sqrt{\frac{D}{b^{1}}} \times \frac{(d+D)}{b}$

where:

b_1 = distance between centre to centre of piles = 57.5M

D = Depth of pile line, the interference of which has to be determined on the neighbouring pile of depth 'd'

= (462.0-1.4-2.5) - 461.0 = (-) 2.9

d = Depth of pile under consideration on which the effect of pile of depth, D is sought to be determined = 8.0-1.4-2.5 = 4.1M

b = total length of floor = 60.0M

Since D has -ve value, the interference correction for ϕE by u/s pile is `nil'

ϕE corrected = 32-7.80 = 24.20% ϕD = 16% ϕC = 0%

Results:-

Description & condition	UPSTREAM CUT OFF			DOWN STREAM CUT OFF		
	ϕE_1	ϕD_1	ϕC_1	ϕE	ϕD	ϕC
No flow	100%	88%	80.717%	24.20%	16%	0%
Static Head	10.4M	9.152	8.295	2.52M	1.66M	0

The net uplift pressure on the u/s floor will be nil as the uplift pressure shall be counterbalanced by the wt. of the standing water. Theoritically no floor thickness is regd. However 1.0m thick floor has been proposed.

Floor thickness at different points:

a) Static Head:

The static head governs the thickness of the floor from the D/s end upto the starting point of the stilling basin and beyond it the dynamic head governs the thickness. Unbalanced head at every 5 M along the floor have been measured and the thickness calculated by dividing the unbalanced head by 2.4 - 1.0 = 1.4 which is the submerged density of concrete.

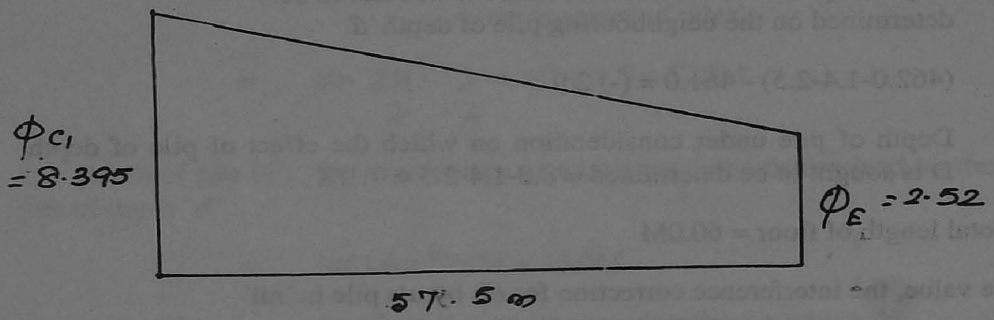
For dynamic condition 2/3 of the value of ordinate measured between the water surface profile and the corresponding ordinate of hydraulic gradient line has been taken to calculate the floor thickness.

i) At downstream end:

Pressure ϕE = 24.2%

Absolute pressure head = $\frac{24.2 \times 10.4}{100} = 2.52$

Floor thickness required = $\frac{2.52}{(2.4-1.0)}$ = 1.80



ii) At 5m from the E of down stream cut off:

Unbalanced head = $2.52 + \frac{5.875}{57.5} \times 5 = 2.52 + 0.51$

= 3.03

Thickness of floor = $\frac{3.03}{1.4}$ = 2.16 or say 2.2m

However adopt a thickness of 2.5m as assumed.

iii) At 10m from the of D/s cut off:

Unbalanced head = $2.52 + \frac{5.875}{57.5} \times 10 = 2.52 + 1.022$

= 3.542

Thickness of floor = $\frac{3.542}{1.4}$ = 2.53 or say 2.6 M

iv) At 15 m from the E of D/s cut off:

Unbalanced head = $2.52 + \frac{5.875}{57.5} \times 15$

= 2.52+1.5333

= 4.053

Thickness of floor = $\frac{4.053}{1.4}$ = 2.895 or say 2.9M

v) At 20M from the E of D/s cut off:

Unbalanced head $= \frac{2.52 + 5.875}{57.5} \times 20$

$= 2.52+2.04 = 4.56$

Thickness of floor $= \frac{4.56}{1.4} = 3.26$ or say 3.3m

vi) At 25M from the E of D/s cut off:

Unbalanced head $= \frac{2.52+5.875}{57.5} \times 25$

$= 2.52+2.55 = 5.07$

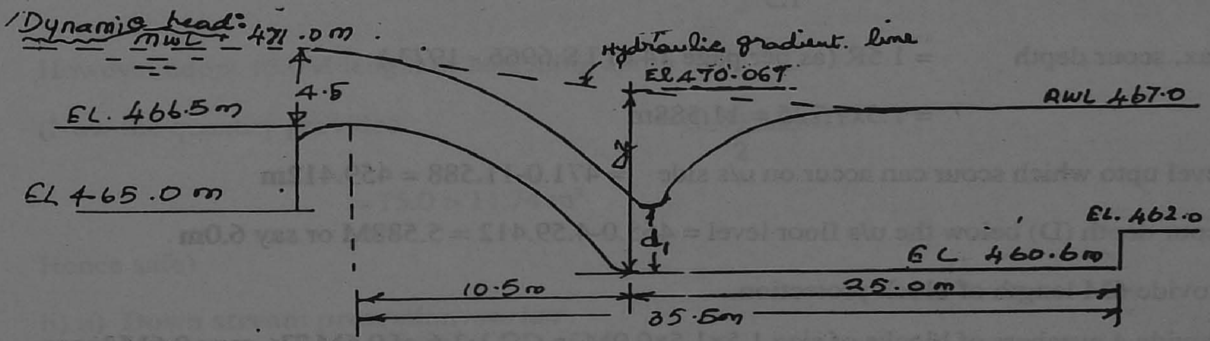
Thickness of Floor $= \frac{5.07}{1.4} = 3.62$M or say 3.7M

vii) At 35.5m from the of D/s cut off:

Unbalnced head $= 2.52+\frac{5.875}{57.5} \times 33.5$

$= 2.52+3.42 = 5.94$

b) Thickness of Floor $= \frac{5.94}{1.4} = 4.24$ say 4.3M



Elevation of hydraulic gradient line at the starting point of stilling basin

$= 4.67+\frac{4}{35.5} \times 25$

$= 467+2.82 = 469.82$m

Dynamic head = 469.82 (stilling basin floor elevation $+d_1$)

= 469.82 - (460.6+1.508)

= 469.82 - 462.108 = 7.712

Unbalanced dynamic head = 2/3x7.712 = 5.141

Thickness required = $\frac{5.141}{1.4}$ = 3.67M

Hence thickness of apron provided at starting point of stilling basin **3.8m.**

Design of u/s and D/s protection works:

i) a) U/s block protection works:

Just beyond the u/s end of the impervious floor previous protection **comprising of C.C. blocks** 1.5 x 1.5 x 0.9m

laid over loose stone, shall be provided.

Length of u/s block protection = D, the scour depth below floor level.

Clear distance between face to face of the abutments assuming 3 m tk. piers

= 3x11.3+2x3 = 33.9+6.0 = 39.9m

Intensity of discharge = $\frac{669.22}{39.9}$ = 16.77 cumecs

Scour depth, R = $1.35\left(\frac{16.77^2}{1.5}\right)^{1.3}$ = 7.725 m

Max. scour depth = 1.5R (as per page 14 of I.S.6966 - 1973.)

= 1.5x7.725 = 11.588m

Level upto which scour can accur on u/s side = 471.0-11.588 = **459.412m**

Scour depth (D) below the u/s floor level = 465.0-4.59.412 = 5.588M or say **6.0m**

Provide 6M length of block protection.

Provide 4 numbers of blocks of size 1.5x1.5x0.9M in CC 1:3:6 of 0.6M Tk. over **0.6M loose** stone packing with a retaining wall of 0.6m Tk. at the end of blocks.

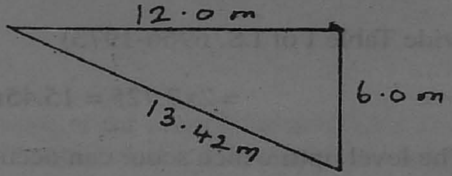
b) Upstream side launching apron:

The length of launching apron proposed = 2 D

= 2x6 = 12M

Adopting 2:1 slope for launching pposition of the apron, length at the launched position.

$$=\sqrt{12^2 + 6^2} = 13.42\text{m}$$



Bed slope of the proposed surplus course = 1/2960

Referring to table - 2. of I.S. 6966-1973, (criteria for hydraulic design of barrages and weirs) thickness of pitching (T) for loose stone protection in mm, maximum bed slope = 0.4m/Km

The bed material is taken as very coarse and from the table, T = 700mm or 0.7 m is taken for the design.

The quantity of pitching required to be laid in 13.42m length is to be spread out in horizontal portion of 12.0m length.

Thickness of launching apron $= 13.42 \times \frac{0.7}{12}$

$= 13.42 \times 0.0583$

$= 0.783$ or say 0.8m

0.25 T, for wedge portion $= 0.25 \times 0.8 = 0.2$M

This will be provided in the form of a triangle with zero metre at the inner edge and 0.2x2 = 0.4m thickness at the outer edge (i.e) total thickness of 0.8m at the inner edge and 1.2m at the outer edge.

As per para 18.3.4 of I.S. 6966 - 1973, 1.25 T $= 1.25 \times 0.7 = 0.875$

The quantity of launching apron regd/m run $= 1.0 \times 13{,}42 \times 0.875 = 11.74\text{M}^3$

The quantity provided/m.run $= \frac{(0.8+1.2)}{2} \times 12 \times 1 = 12.0\text{M}^3$

However adopt 15.0M length of launching apron

(Now the quantity provided $= \frac{(0.8+1.2)}{2} \times 15$

$= 15.0 > 11.74\ \text{m}^3$

Hence safe)

ii) a) **Down stream protection works:**

Pervious block protection shall be provided just beyond the D/s end of the impervious floor. The size of block is 1.5 x 1.5 x 0.9M to be laid, with gaps of 75mm width packed with gravel.

Scour depth, R $= 1.35 \left(\frac{16.77^2}{1.5}\right)^{1/3} = 7.725$M

Scour for down - Stream impervious floor = 2 R

(vide Table I of I.S. 6966-1973)

= 2x7.725 = 15.45m

The level upto which scour can occur = RWL.467.0-15.45

= 451.55m

Design depth below floor level(D) = 462.0-451.55

= 10.45

Length of D/s block protection = 1.5D

= 1.5x10.45 = 15.675m

Provide 11 Nos. of CC blocks in 1:3:6 mix of size 1.5x1.5x0.9m with 7.5 cm gravel packing in between the blocks and with end retaining wall of 0.6m thickness.

Length of block protection = 1.5x11+0.075x10

= 16.5+0.75 = 17.25M>15.675m (required)

This 17.25m length of block protection is provided over 0.6m thick inverted filter.

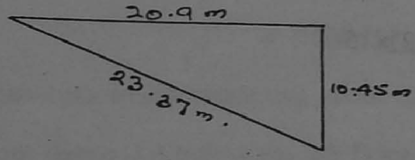
Down stream side launching apron:

The length of launching apron proposed = 2xD

= 2x10.45 = 20.9m

Adopting 2:1 slope for launching position of the apron,

length at the launched position = $\sqrt{20.9\ 2+10,45^2}$



= $\sqrt{436.81+109.203}$

= $\sqrt{546.0/3}$

=23.3669

Bed slope of the surplus coarse = 1/2960.

Referring to table 2 of I.S. 6966 -1973, (criteria for hydraulic design of barrages and weirs) thickness of pitching (T) for loose stone protection in mm, maximum bed slope = 0.4m/km. The bed material is taken as very coarse. From the table, T = 700 mm or 0.7m. The quantity of pitching required to be laid in 23.37m length is to be spread out in horizontal portion of 20.9m length

Thickness of launching apron $= 23.37 \times \frac{0.7}{20.9} = 0.78$ or say 0.8m

0.25 T, for wedge portion $= 0.25 \times 0.8 = 0.2$m

This will be provided in the form of a triangle with zero metre at the inner edge and 0.2 x 2 = 0.4m thickness of the outer edge of launching apron, (i.e) total thickness of 0.8m at the inner edge and 1.2m at the outer edge.

As per para 18.3.4 of I.S. 6966-1973, 1.25T

$= 1.25 \times 0.7 = 0.875$

The quantity provided/m.run $= \frac{(0.8+1.2)}{2} \times 20.9 = 20.9M^3$

However adopt 25m length of launching apron
(Now the quantity provided $= \frac{(0.8+1.2)}{2} \times 25$

$= 25M^3 > 20.45M^3$

Hence safe.
As per U.S.B.R.
$V = 4.915 D^{1/2}$

Velocity after jump, $V_2 = 3.08$m/sec

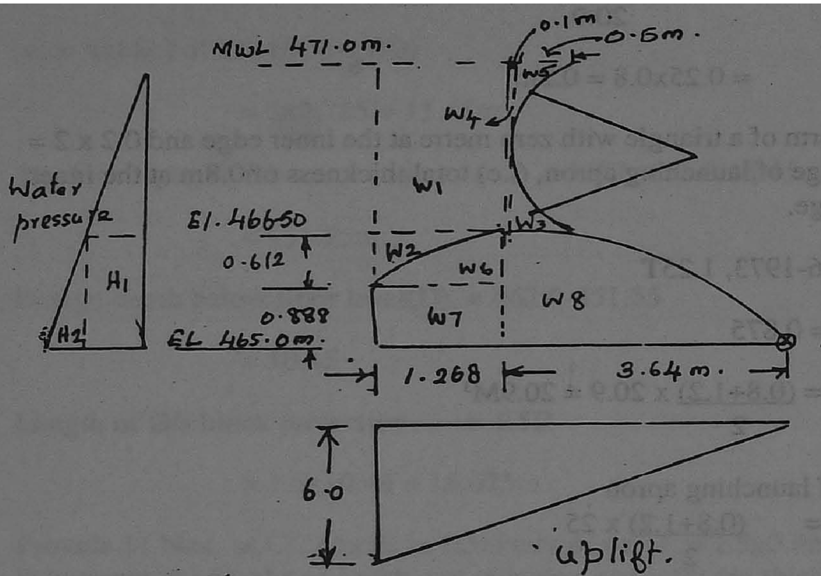
$3.08 = 4.915 D^{1/2} =$

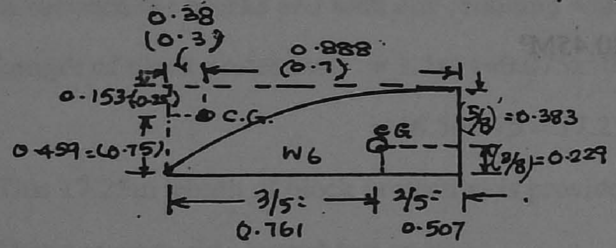
$D^{1/2} = \frac{3.08}{4.915} = 0.627$

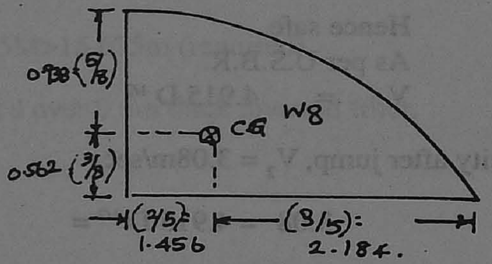
$\therefore D = 0.39$m

The required thickness loose stones = 0.39M
However stone thickness of 0.45 m is adopted for providing launching apron.

Stability check up of spillway at $E\ell$ 465.0m:







Assuming MWL in the u/s side and no water on the D/s side and taking the moments about `A'.

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry					
	$W_6 = 2/3 \times 1.268 \times 0.612 \times 2.4$	1.24		3.64+0.507 = 4.147	5.15	
	$W_7 = 1.268 \times 0.888 \times 2.4$	2.7		3.64+0.634 = 4.274	11.55	
	$W_8 = 2/3 \times 3.64 \times 1.5 \times 2.4$	8.736		2.184	19.08	
	Reservoir empty	12.676			35.78	
2.	Wt. of water:					
	$W_1 = 4.5 \times 1.268 \times 1.0$	5.706		4.274	24.39	
	$W_2 = 1/3 \times 1.268 \times 0.612 \times 1.0$	0.259		3.64+0.888 = 4.528	1.17	
	$W_3 = 1/2 \times 0.5 \times 2.25 \times 1$	0.5625		3.04+2/3x0.5 = 3.373	1.9	
	$W_4 = 4.5 \times 0.1z1$	0.45		3.59	1.62	

Description	V	H	L.A.	Moments +ve	Moments -ve
W_5 (wt. of water over the gate) neglected					
3. Water pressure:					
H1 = 4.5x1.5x1.0		6.75	1.5/2=0.75		5.06
H2 = 1/2x1.5x1.5x1.0		1.125	1.5/3=0.5		0.563
4. Uplift = 1/2x6x4.908	(-)14.724		2/3x4.908 = 3.272		48.18
εV	4.93	εH=7.875		64.86	53.803

Reservoir Empty =

$$X = \frac{\varepsilon m}{\varepsilon V} = \frac{35.78}{12.676} = 2.82$$

Eccentricity, e $= b/2 \sim X = \frac{4.908}{2} \sim 2.82$

$= 2.454 \sim 2.82 = 0.366$

6 e/b $= 6x0.366/4.908 = 0.447$

max. stress $= \frac{12.676}{4.908.}(1+0.447) = 3.74 t/m^2$ (comp)

Min. stress $= \frac{12.676}{4.908}(1-0.447)$

$= 1.43 t/m^2$ (comp) Hence safe.

Reservoir fall:

εM $= 64.86 - 53.803 = 11.057$

X $= \varepsilon m = \frac{11.057}{\varepsilon V \quad 4.93} = 2.243$

centricity, e= b/2 ~ X = 2.454-2.243 = 0.211

6 e/b $= \frac{6x0.211}{4.908} = 0.258$

Max. stress = $\frac{4.93}{4.908}(1+0.258) = 1.26 t/m^2$ (comp)

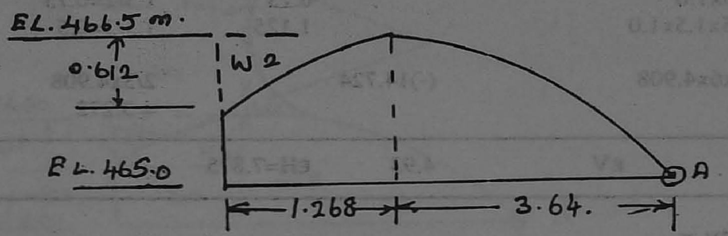
Min. stress = $\frac{4.93}{4.908}(1-0.258) = 0.75 t/m^2$ (comp)

Hence safe.

To avoid sliding and to have more stability against water thrust, the achor rods provided in the crest portion of the spill way is taken into the spillway body wall with sufficient anchorage.

The stability of the spillway is checked for the following three conditions as in the case of submerged weir:

Condition I = u/s water level is at crest elevation and no water in the D.s side.



Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry	12676		1.213	35.78	
2.	Wt. of water $W_2 = 1/3 x 1.268 x 0.612 x 1.0$	0.259		4.528	1.17	
3.	Water pressure: $1/2 x 1 x 1.5_2$		1.125	1.5/3=0.5	0.563	
4.	Uplift=1/2x1.5x4.908	(-)3.681		3.272		12.044
	εV =	9.254			36.95	12.607

εm = 24.343

$\chi = \frac{24.343}{0.254} = 2.63$

eccentricity, e = 2.45 ~ 2.63 = 0.176

6 e/b = $\frac{6x0.176}{4.908} = 0.215$

Max.stress = $\frac{9.254}{4.908}$ (1+0.215) = 2.29 t/m² (comp)

Min.stress = $\frac{9.254}{4.908}$ (1-0.215) = 1.48 t/m² (comp)

Stability factor = $\frac{+M}{-M} = \frac{36.95}{12.607}$ = 2.9>1.5 Hence safe.

Sliding factor = $\frac{εH}{εV} = \frac{1.125}{9.254}$ = 0.12<0.75 Hence safe.

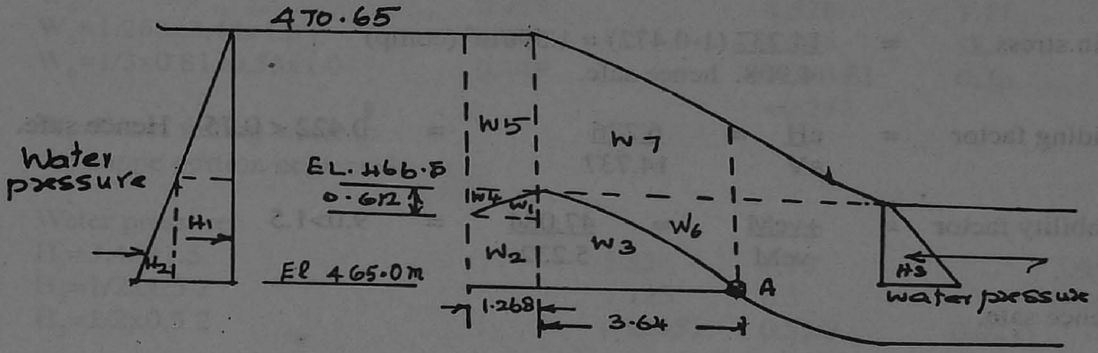
Condition II : Water passing over the spillway and tailwater at crest level:

When the rear water depth is 6.4 m (i.e. 4670-460.6) head over the crest = 4.5

when the rear water depth is 5.9 (i.e. (466.5-46.6)

head over crest $= \frac{5.9 \times 4.5}{6.4} = 4.15m$

The spillway is under submerged condition and the submerged wt. of concrete 1.4 t/M³ (i.e. 2.4-1.0) has been taken into account.



Stability check up at EL 465.0M, Taking moments about A:

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry:					
	W_1=2/3x1.268x0.612x1.4	0.724		4.147	3.004	
	W_2=1.268x0.888x1.4	1.576		4.274	6.737	
	W_3=2/3x3.64x1.5x1.4	5.096		2.184	11.13	
2.	Wt.of water:					
	W_4=1/3x1.268x0.612x1.0	0.259		4.528	1.17	
	W_5=1.268x4.15x1.0	5.262		4.274	22.49	
	W_6=1/3x3.64x1.5x1.0	1.82		1.092	1.99	
	W_7=Wt.of following water in the nappe portion. neglected.					
3.	Water pressure:					
	H_1=4.15x1.5		6.225	0.75		4.669
	H_2=1/2x1.5²		1.125	0.5		0.563
	H_3=(-)1/2x1.5²		(-)1.125		0.563	
	εV =	14.737	εH=6.225		47.084	5.232

εM = 41.852.

$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{41.852}{14.737} = 2.84$

eccentricity, e b/2 ~ x = 2.454 ~ 2.84 = 0.386

$6\ e/b = \frac{6 \times 0.386}{4.908} = 0.472$

Max.stress $= \frac{14.737}{4.908}(1+0.472) = 4.42\ t/m^2$ (comp)

Min.stress $= \frac{14.737}{4.908}(1-0.472) = 1.59 t/m^2$ (comp) hence safe.

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{6.226}{14.737} = 0.422 < 0.75$. Hence safe.

Stability factor $= \frac{+veM}{-veM} = \frac{47.084}{5.232} = 9.0 > 1.5$

Hence safe.

Condition III:

Water passing over the spillway and the tail water level at $H\sqrt{K}$ above the base of Spillway $K = \frac{\text{Head over crest}}{\text{Tailwater depth}} = \frac{4.5}{6.4} = 0.703$

$\sqrt{K} = 0.839$

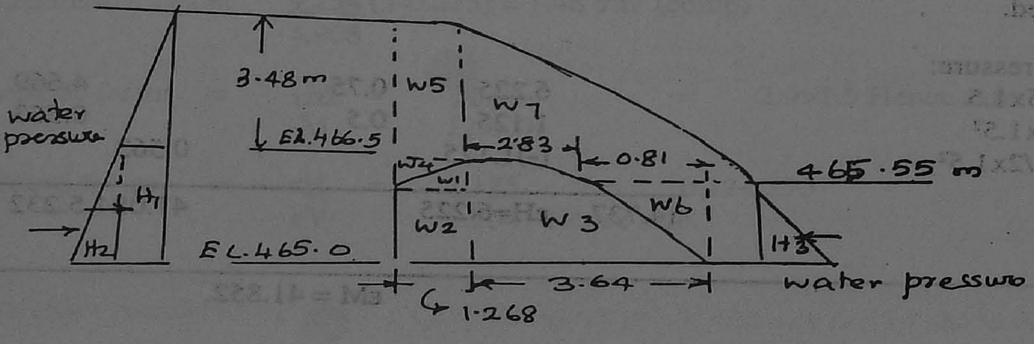
H. ht. of spillway = 466.5 - 460.6 = 5.9m

$H\sqrt{K} = 5.9 \times 0.839 = 4.95M$

Tailwater level = 460.6+4.95 = 465.55m

When the tailwater depth is 4.95m

Head over crest $= \frac{4.5}{6.4} \times 4.95 = 3.48$ m



Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry:					
	W_1	0.724		4.147	3.004	
	W_2	1.576		4.274	6.737	
	W_3	5.096		2.184	11.13	
2.	Wt. of water:					
	W_4	0.259		4.528	1.17	
	W_5=1.268x3.48x1.0	4.41		4.274	18.86	
	W_6=1/3x0.81x0.55x1.0	0.149		0.3x0.81 =0.243	0.36	
	W_7=Wt.of falling water in the nappe portion neglected.					
3.	Water pressure:					
	H_1=3.48x1.5		5.22	0.75		3.915
	H_2=1/2x1.5 2		1.125	0.5		0.563
	H_3=1/2x0.5 2		(-)0.151	0.55/3 =0.183	0.0277	
	εV =	12.214	εH=6.194		40.9647	4.478

εm = 36.4867

X = $\frac{\varepsilon M}{\varepsilon V}$ = $\frac{36.4867}{12.214}$ = 2.99

eceentricity, e = b/2 ~ X = 2.454 ~ 2.99 = 0.536

6 e/b = $\frac{6x0.536}{4.908}$ = 0.655

Max. stress = $\frac{12.214}{4.908}$ (1+0.655) = 4.12 t/m² (Comp)

Min.stress = $\frac{12.214}{4.908}$ (1-0.655) 0.86 t/m² (comp)

Sliding factor = $\frac{\varepsilon H}{\varepsilon V}$ = $\frac{6.194}{12.214}$ = 0.51<0.75

Hence safe.

Stability factor = $\frac{R.M}{OM}$ = $\frac{40.9647}{4.478}$ = 9.2>1.5

Hence safe.

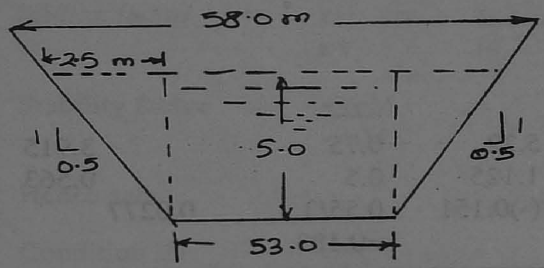
Design of surplus course:

Max. flood discharge = 654.9 cumecs (23127 c/s) discharging capacity of the spillway = 669.22 cumecs (23633.65 c/s)

The surplus course is to be designed for the maximum of the above (i.e) for 669.22 cumecs (23663.65 c/s)

Assume the bed width of surplus course as 53.0M.
The surplus course is proposed in cutting. Hence a side slope of 1/2:1 is considered for design purpose.

Full supply depth = 5.0M.



Area of flow = $(53.0+2.5)^5 = 277.5m^2$

Max. permissible velocity of flow = 8^1/sec (or 2.438m/sec)
Discharge in the surplus course = 277.5x2.438
= 676.545>669.22 cumecs (required)

Wetted perimeter, P = $53+2\sqrt{5^2+2.5^2}$
= $53+2\sqrt{25+6.25}$
= 53+11.18 = 64.18M

Hydraulic mean depth, R = $\frac{A}{P} = \frac{277.5}{64.18} = 4.324$

Velocity of flow as per Mannings formula $v = 1/n\ R^{2/3}\ S^{1/2}$

$$2.438 = 1/0.02\ (4.324)^{2/3}\ S^{1/2}$$

$$\therefore S^{1/2} = \frac{0.02 \times 2.438}{(4.324)\ 2/3} = \frac{0.04876}{2.654} = 0.01837$$

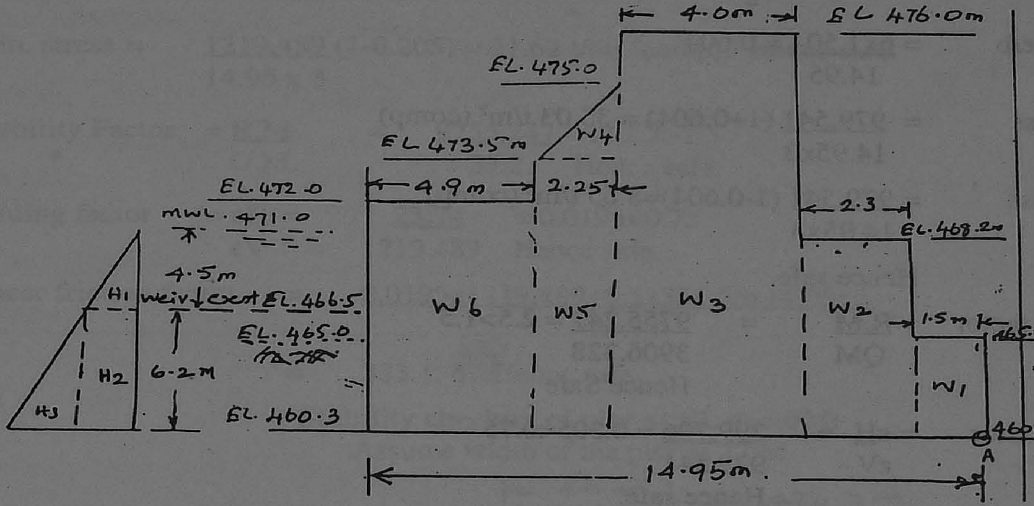
$$\therefore S = 0.0003375 \text{ or } 1/2962.9$$

Adopt a longitudinal slope of 1 in 2960.

The Chief Engineer (Irrigation) has given instruction that the velocity of flow in the surplus course may be limited to 8^1/sec (2.438 m/sec)
Vide C.E. (I) Memo No.P4/15737/79-15. dt.28.02.80.

The velocity of flow at the end of stilling basin is 3.08 m/sec (V_2). Hence the guide wall has been taken beyond the stilling basin and upto the end of block protection works where the velocity of flow gets reduced to 2.438 m/sec.

Design of Pier:



Stability check up at Foundation EL.460.3m, Taking moments about `A'

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry					
	W_1=1.5x4.7x3.0x2.3	48.645		0.75	36.484	
	W_2=2.3x7.9x3x2.3	125.373		1.5+1.15=2.65	332.238	
	W_3=4x15.7x3x2.3	433.32		5.8	2513.256	
	W_4=1/2x2.25x1.5x3x2.3	11.644		7.8+2.25/3=8.55	99.556	
	W_5=13.2x2.25x3x2.3	204.93		7.8+2.25/2=8.925	1829.000	
	W_6=11.7x4.9x3x2.3	395.577		14.95-4.9/2=12.5	4944.713	
		1219.489			9755.247	
2.	Earth pressure, PA					
	PA=3x1/2x1.332x4.7 $^2\left(\frac{1-\sin32^o}{1+\sin32^o}\right)$		13.558	$\frac{4.7}{3}$=1.567		21.245
3.	Hydrastatic Pressure:					
	H1=1/2x4.5²x(11.3+3.0)		144.788	6.2+4.5/3=7.7		1114.868
	H2=4.5x6.2x3		83.7	6.2/2=3.1		259.47
	H3=1/2x6.2x3		57.66	6.2/3-2.067		119.183
4.	Uplift:					
	1/2x10.7x14.95x3x1	(-)239.948		2/3x14.95 =9.967		2391.562
	εV	979.541	εH=299.706		9755.247	3906.328
			εM	= 5848.919		

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{5848.919}{979.541} = 5.971$$

Eccentricity, e $= b/2 \sim \chi = \frac{14.95}{2} - 5.971 = 7.475 - 5.971 = 1.504$

6 e/b $= \frac{6 \times 1.504}{14.95} = 0.604$

Max.stress $= \frac{979.541}{14.95 \times 3}(1+0.604) = 35.03\ t/m^2$ (comp)

Min. stress $= \frac{979.541}{14.95 \times 3}(1-0.604) = 8.65\ t/m^2$ (comp)

Hence safe.

Stability factor $= \frac{R.M}{QM} = \frac{9755.247}{3906.328} = 2.5 > 1.5$

Hence Safe

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{299.706}{979.541} = 0.305 < 0.75$

Hence safe.

Shear friction factor $= \frac{0.305 \times 979.541 + 0.5 \times 351.55 \times 14.95 \times 3}{299.706}$

$= 27.3 > 5$ Hence safe.

Reversion Empty:

Stability check up at foundation Eℓ 460.3M (Taking moments about `A')

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:	1219.489			9755.247	
2.	Earth pressure PA= $3 \times 1/2 \times 2.332 \times 4.7^2 \left(\frac{1-\sin 32^\circ}{1+\sin 32^\circ}\right)$ = 23.74		23.74	$\frac{4.7}{3}$=1.567		37.2
			ΕH =		9755.247	37.2
	ΕV =	1219.489	23.74	ΕM = 9718.047		

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{9718.047}{1219.489} = 7.97$$

Eccentricity, e $= b/2 \sim \chi$

$= \frac{14.95}{2} \sim 7.97 = 7.46 \sim 7.97$

$= 0.51$

6 e/b = $\frac{6x0.51}{14.95}$ = 0.205

Max. stress = $\frac{1219.489}{14.95x3}$ (1+0.205) = 32.76 t/m² (comp)

Min. stress = $\frac{1219.489}{14.95 \times 3}$ (1-0.205) = 21.62 t/m² (comp). Hence safe.

Stability Factor = $\frac{R.M}{O.M.}$ = $\frac{9755.247}{37.2.}$ = 262.2>1.5 Hence safe.

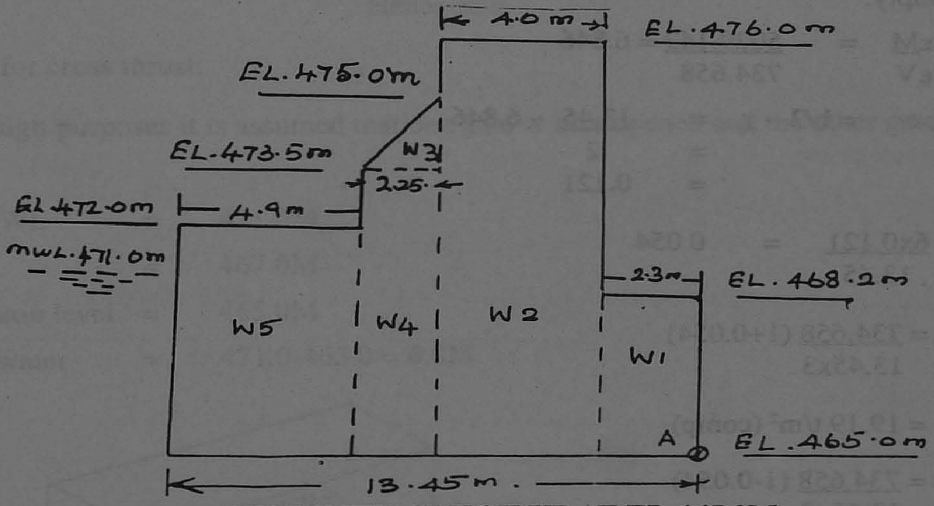
Sliding factor = $\frac{\varepsilon H}{\varepsilon V}$ = $\frac{23.74}{1219.489.}$ = 0.0195<0.75 Hence safe.

Shear friction factor = $\frac{0.0195x1219.489+0.5x351.55x14.95x3}{23.74}$

= 333.1>5. Hence safe.

Stability checkup of pier at EL 465.0M:

Assume width of the pier as 3.0M



STABILITY CHECK UP AT EL 465.0M

Taking moments about `A'

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:					
	W1=2.3x3x3.2x2.3	50.784		2.3/2=1.15	58.40	
	W2=4x11x3x2.3	303.60		4.3	1305.48	
	W3=3x1/2x2.25x1.5x2.3	11.664		6.3+$\frac{2.25}{3}$ =7.05	82.09	
	W4=8.5x2.25x3x2.3	131.96		6.3+$\frac{2.25}{2}$ =7.425	979.803	

Sl. No.	Description	V	H	L.A.	Moments (+)	Moments (−)
	W5=7x4.9x3x2.3	236.67		13.45-$\frac{4.9}{2}$ =11.00	2603.37	
	Reservoir empty	734.658			5029.143	
2.	Water pressure 1/2x6² (11.3+3.0)		257.40	6/3=2.0		514.80
3.	Uplift 1/2x6x13.45x3x1	(-)121.05		2/3x13-45 =8.97		1085.82
					5029.143	
	εV =	613.608				1600.62

εM = 3428.523

Stress calculations:

Reservoir empty:

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{5029.143}{734.658} = 6.846$$

eccentricity, e $= b/2 \sim \chi = \frac{13.45}{2} \sim 6.846 = 0.121$

$$6\,e/b = \frac{6x0.121}{13.45} = 0.054$$

$$\text{Max. stress} = \frac{734.658}{13.45x3}(1+0.054)$$

= 19.19 t/m² (comp)

$$\text{Min. Stress} = \frac{734.658}{13.45x3}(1-0.054)$$

= 17.22 t/m² (comp). Hence safe.

Reservoir full:

$$X = \frac{3428.523}{613.608} = 5.587$$

Eccentricity, e = 6.725-5.587 = 1.138

$$6\,e/b = \frac{6x1.138}{13.45} = 0.5077$$

$$\text{Max.stress} = \frac{613.608}{13.45x3}(1+0.5077) = 22.93 \text{ t/m}^2 \text{ (comp)}$$

Min.Stress = $\frac{613.608}{13.45x3}$ (1-0.5077) = 7.486 t/m² (comp)

Hence safe :

Stability factor = $\frac{R.M}{O.M}$ = $\frac{5029.143}{1600.62}$ = 3.14>1.5

Hence safe.

Sliding factor = $\frac{\varepsilon H}{\varepsilon V}$ = $\frac{257.4}{613.608}$ = 0.419<0.75

Hence safe.

Shear friction factor = $\frac{C\varepsilon V+rsaA}{\varepsilon H}$

= $\frac{0.419x613.608+0.5x351.55x13.45x3}{257.4}$

= 28.55 > 5.0

Hence safe.

Check for cross thrust:

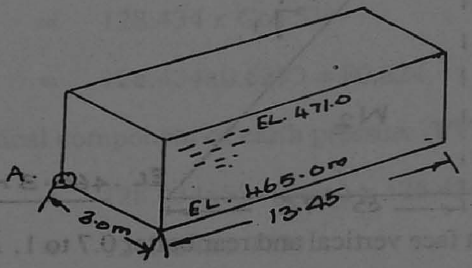
For design purposes it is assumed that one gate is kept opened and the other gates are closed:

U/S MWL = 471.0M

R.W.L. = 467.0M

U/S apron level = 465.0M

Ht. of water = 471.0-465.0 = 6.0M



Water pressure is assumed as 50% (as per page 2/2 of Ellis) on one side.
Taking moments about A, stability checkup at EL 465.0 for cross thrust:

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry:	734.658		3/2=1.5	1101.99	
2.	Water pressure:					

	1/2x6x6x13.45x1/2		121.05	6/3=2.0		242.1
3.	Water pressure on opposite side:					
	1/2x6x6x5		(-)90.00	2.0		(-)180.0
	1/2x2x2x8.45		(-)16.9	2/3=0.667		(-)11.27
	ƐV	734.658	ƐH=14.15		1101.99	50.83
				ƐM =	1051.16	

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{1051.16}{734.658} = 1.431$$

Eccentricity, e $= b/2 \sim \chi = 1.5 - 1.431 = 0.069$

$$6\,e/b = \frac{6 \times 0.069}{3} = 0.138$$

Maximum or minimum stress $= \frac{734.658}{13.45 \times 3}(1 \pm 0.138)$

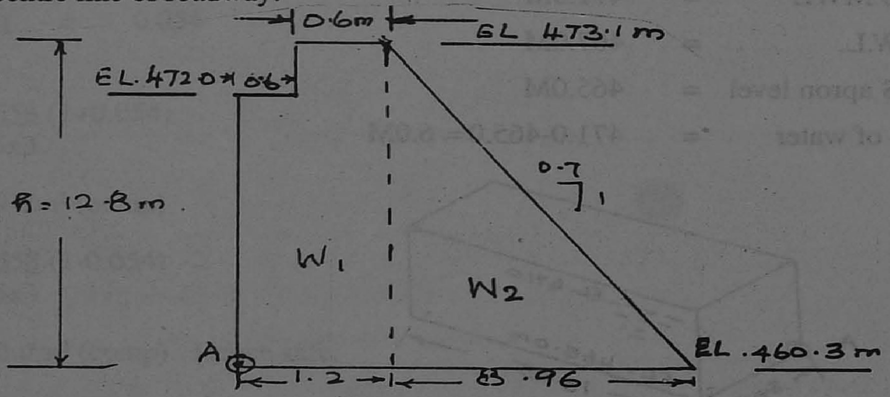
$= 20.72\ t/m^2$ (comp)

$= 15.69\ t/m^2$ (comp)

Hence safe.

Design of Abutment:

i. Section `CC' at centre line of roadway:



Assume top width of abutment as 1.2M with front face vertical and rear batter 0.7 to 1. Angle of internal friction of soil, $\phi = \phi\ 32^0$(for SPZ)

α = Angle which earth face of wall makes with the vertical.

Tan $\alpha = 0.7/1 = 0.7$

$\therefore \alpha = \tan^{-1} 0.7 = 35^0$

i = Slope of earthfill = 0.

δ = Angle of triction between wall and earth fill

$$= \frac{\phi}{2} = \frac{32}{2} = 16^0$$

w = Saturated wt. of soil = 2332 kg/m³ (for SPZ)

Static active earth pressure, PA = 1/2 wh² Ca

Where Ca = $\frac{\cos^2(\phi-\alpha)}{\cos^2\alpha \cos(\delta+\alpha)}$ X $\frac{(1+\sin\phi(\delta)\sin\phi(-i)}{\cos(\alpha-i)\cos(\delta+\alpha)}$

$\cos(-\alpha) = \cos(32°-35°) = \cos(-3°) = \cos 3° = 0.9986$

$\cos\alpha = \cos 35° = 0.8192$

$\cos(\delta+\alpha) = \cos(16°+35°) = \cos 51° = 0.6293$

$\sin(\phi+\delta) = \sin(32°+16°) = \sin 48° = 0.7431$

$\sin(\phi-\iota) = \sin(32°-0°) = \sin 32° = 0.5299$

$\sin(\alpha+\delta) = \sin(35°+16°) = \sin 51° = 0.7771$

$$Ca = \frac{0.9986 \times 0.9986}{0.8192 \times 0.8192 \times 0.6293} \times \left\{ \frac{1}{1+\sqrt{\frac{0.7431 \times 0.5299}{0.8192 \times 0.6293}}} \right\}^2$$

$$= 2.3613 \times \left(\frac{1}{1+0.8740}\right)^2$$

$$= 2.3613 \times 0.2847 = 0.6723$$

Static active earth pressure, PA = 1/2 wh² Ca

= 1/2x2.332x12.8²x0.6723

= 128.434

Horizontal component of earth pressure, PH = 128.434xCos (δ+α)

= 128.434 x Cos 51°

= 128.434x0.6293 = 80.824

Vertical component of earth pressure (PV):

P_v = 128.434xSin (δ+α) = 128.434xSin 51°

= 128.434x0.7771

= 99.81

Stability check up at El 460.3M, Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry: W1=1.2x12.8x2.3		35.328	0.6	21.197	

Sl. No.	Description	H	V	Lever arm	Moments (+)	Moments (−)
	W2=1/2x8.96x12.8x2.3		131.891	1.2+$\frac{8.96}{03}$ =(4.187)	552.228	
	Deduct:0.6x1.1x2.3		(-)1.518	0.3	(-)0.455	
2.	Earth pressure: PH=Heri.component	80.824		$\frac{12.8}{3}$ = 4.267		344.876
	PV=Verti.component		99.81	1.2+2/3x8.96 =7.173	715.937	
	εH =	80.824	εV=265.511		1288.907	344.876

εM = 944.031

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{944.031}{265.511} = 3.556$$

eccentricity, e $= b/2 \sim \chi = \frac{10.16}{2} - 3.556 = 1.524$

$= 5.08 - 3.556 = 1.524$

$$6\,e/b = \frac{6 \times 1.524}{10.16} = 0.9$$

Max. stress $= \frac{265.511}{10.16}(1 \pm 0.9) = 49.65\ t/m^2$ (comp)

Hence safe.

Min. stress $= \frac{265.511}{10.16}(1 \pm 0.9) = 2.61\ t/m^2$ (comp) Hence Safe.

Stability factor $= \frac{R.M}{O.M} = \frac{1288.907}{344.876} = 3.74 > 1.5$

Hence safe.

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{80.824}{265.511} = 0.3 < 0.75$

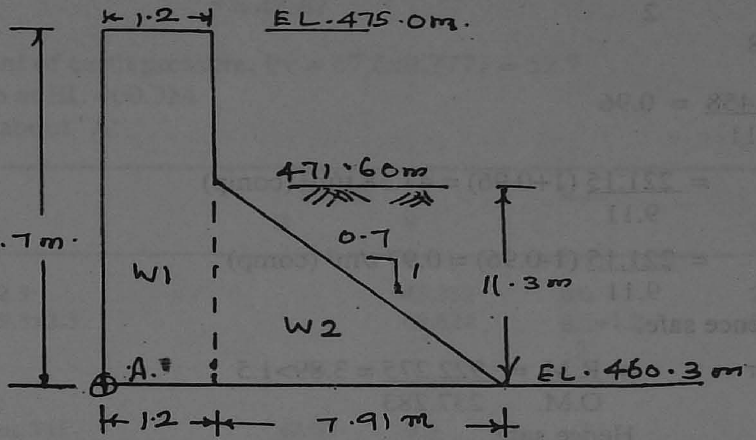
Hence safe

Shear friction factor (sf) : As per the test results on concrete and rock specimens value ofshear strength varies from 300 to 700 ebs/sq.inch. (vide page 298, Engineering for dams, Volume II by creager, Justin & Hinds) The average value of shear strength,(300+700)/2 = 500 lbs/sq.inch or 351.55 t/M² is taken for design purpose.

$$Sf = \frac{0.3 \times 265.511 + 0.5 \times 351.55 \times 10.16}{80.824} = 23.1 > 5$$

Hence safe.

ii) Section `DD' (At 4.75 M from the of road way)



Assume top width of abutment as 1.2M with front face vertical. Rear batter of 0.7 H to 1 V has been proposed at EL.471.6M, the level upto which earth bund has to be retained

Static active earth pressure, PA = 1/2 Wh^2 Ca

= 1/2x2.332x11.3^2x0.6723

= 100.10

Horizontal component of earth pressure PH = 100.1x0.6293 = 62.99

vertical component of earth pressure, PV = 100.1x1x0.7771 = 77.788

Stability check up at EL 460.3M. Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:					
	W_1=1.2x14.7x2.3		40..572	0.6	24.343	
	W_2=1/2x7.91x11.3x2.3		102.79	1.2+7.91/3 = 3.837	393.41	
2.	Earth pressure:					
	Hori.component, PH	62.99		11.3/3 =3.767		237.283
	Vert.component, Pv		77.788	1.2+2/3x7.91 = 6.473	503.522	
	εH = 62.99		εV=221.15		922.275	237.283

εM = 922.275-237.283

= 684.992

$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{684.992}{221.15} = 3.097$

e $= b/2 \sim \chi = \frac{9.11}{2} - 3.097 = 4.555 - 3.097$

$= 1.458$

$6\,e/b = \frac{6x1.458}{9.11} = 0.96$

Max. stress $= \frac{221.15}{9.11}(1+0.96) = 47.58\ t/m^2$ (comp)

Min. stress $= \frac{221.15}{9.11}(1-0.96) = 0.97\ t/m^2$ (comp)

Hence safe.

Stability factor $= \frac{R.M.}{O.M.} = \frac{922.275}{237.283} = 3.89 > 1.5$

Hence safe.

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{62.99}{221.15} = 0.28 < 0.75$

Hence safe.

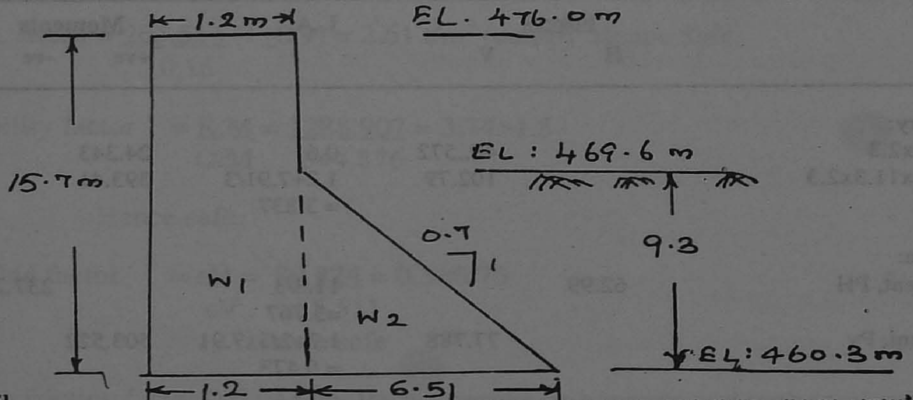
Shear friction factor (Sf):

$$S_f = \frac{0.28x221.15+0.5x351.55x9.11}{62.99}$$

$= 26.42 > 5.$

Hence safe.

iii) **Section `EE' (At 8.75 M from the of roadway)**



Ass[illegible] vertical. Rear batter of 0.7 H to 1V has been proposed at EL 469.6M the level upto which earth bund has to be retained.

Static active earth pressure, PA $= 1/2\ wh^2\ Ca$

$= 1/2x2.332x9.3^2x0.6723$

$= 67.8$

Horizontal component of earth pressure, PH = 67.8x0.6293
= 42.67

Vertical component of earth pressure, Pv = 67.8x0.7771 = 52.7
Stability check up at EL 460.3M
Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry					
	W_1=1.2x15.7x2.3		43.332	0.6	26.0	
	W_2=1/2x65.1x9.3x2.3		69.624	$\frac{6.5}{3}$+1.2 = 3.37	234.633	
2.	Earth pressure:					
	Hori.component, PH	42.67		9.3 =3.1		132.277
	Vert.component, Pv		52.7	2/3x6.54+1.2 =5.54	291.958	
	εH	= 42.67	εV=165.656		552.591	132.277

εM = 420.314

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{420.314}{165.656} = 2.537$$

$$e = b/2 \sim \chi = \frac{7.71}{2} - 2.537 = 3.855 - 2.537 = 1.318.$$

$$6\,e/b = \frac{6\times1.318}{7.71} = 1.026$$

$$\text{Max.stress} = \frac{165.656}{7.71}(1+1.026) = 43.53\ t/m^2\ \text{(comp)}$$

Hence safe.

$$\text{Min.stress} = \frac{165.656}{7.71}(1-1.026) = (-)\ 0.56\ t/m^2\ \text{(tensile)}$$

The tension developed is within the allowable limit of 1 Kg/CM^2 as per CE (I)'s Circular No.A4/21054/75-1 dt.08.04.75.

Hence safe.

$$\text{Stability factor} = \frac{R.M}{O.M} = \frac{552.591}{132.277} = 4.18>1.5$$

Hence safe

$$\text{Sliding factor} = \frac{\varepsilon H}{\varepsilon V} = \frac{42.67}{165.656} = 0.26<0.75$$

Hence safe

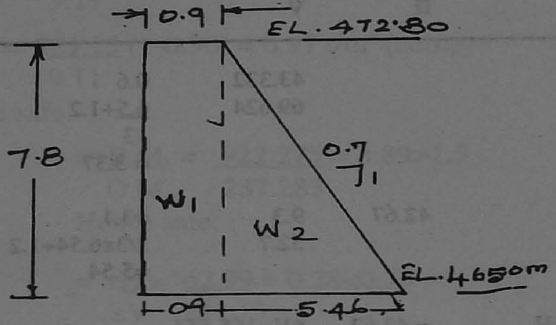
Shear friction factor = $\frac{0.26x165.656+0.5x351.55+7.71}{42.67}$

= 32.8>5.

Hence safe.

Design of Wing Wall:

i) U/S wing wall, maximum section (Section `BB')



Assume top width of wing wall as 0.9m with front face vertical and rear batter 0.7H to 1V. Top level of wing wall is kept at the level upto which earth bund has to be retained (i.e) at EL 472.8M)

Static active earth pressure PA = 1/2 wh² Ca
= 1/2x2.332x7.8²x0.6723
= 47.67

Horizontal component of earth pressure, PH
= 47.69x0.6293 = 30.01

Vertical component of earth pressure Pv
= 47.69x0.7771 = 37.06

Stability check up at EL 465.0M

Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt. of masonry:					
	W1=0.9x7.8x2.3		16.146	0.45	7.266	
	W2=1/2x5.46x7.8x2.3		48.98	0.9+1/3x5.46 =2.72	133.226	
2.	Earth pressure					
	Hor.component.PH	30.01		7.8/3=2.6		78.026
	Ver.component.Pv		37.06	2/3x5.46+0.9 =4.54	168.252	
		εH 30.01	εV=102.186		308.744	78.026

εM = 230.718

$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{230.718}{102.186} = 2.2558$

eccentricity, e $= b/2 \sim \chi = \frac{6.36}{2} - 2.258$

$= 3.18 - 2.258 = 0.922$

6 e/b $= \frac{6 \times 0.922}{6.36} = 0.87$

Max.stress $= \frac{102.186}{6.36}(1+0.87)$

$= 30.05\ t/m^2$ (comp)

Min.stress $= \frac{102.186}{6.36}(1-0.87) = 2.09\ t/m^2$ (comp)

Stability factory $= \frac{RM}{O.M.} = \frac{308.744}{78.026.} = 3.96 > 1.5$

Hence safe.

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{30.01}{102.186} = 0.29 < 0.75$

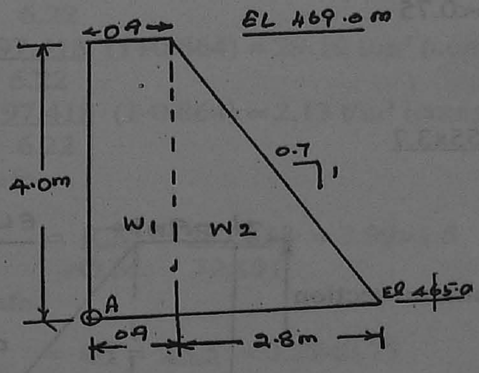
Hence safe

Shear friction factor $= \frac{0.29 \times 102.186 + 0.5 \times 351.55 \times 6.36}{30.01}$

$= 38.25 > 5.$

Hence safe

ii) Upstream wing wall, minimum section, (Section AA):



Static active earth presssure, Pa $= 1/2\ wh^2\ Ca$

$= 1/2 \times 2.332 \times 4^2 \times 0.6723$

$= 12.54$

Hori.component of earth pressure, PH

$= 12.5 \times 0.6293 = 7.89$

Ver.component of earth pressure

$$P_v = 12.54 \times 0.7771 = 9.74$$

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:					
	W1=0.9x4x2.3		8.28	0.45	3.726	
	W2=1/2x2.8x4x2.3		12.88	0.9+2.8/3 = 1.833	23.609	
2.	Earth pressure:					
	Hor.component PH	7.89	4/3=1.333			10.52
	Ver.component Pv		9.74	2/3x2.8+0.9	26.95	
	εM = 43.765					
	εH =	7.89	30.9		54.285	10.52

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{43.765}{30.9} = 1.416$$

eccentricity e $= b/2 \sim \chi = 3.7/2 - 1.416 = 0.434$

6 e/b $= \frac{6 \times 0.434}{3.7} = 0.704$

Max.stress $= \frac{30.9}{3.7}(1+0.704) = 14.23$ t/M² (comp)

Min.stress $= \frac{30.9}{3.7.}(1-0.704) = 2.47$ t/M² (comp)

Hence safe

Stability factor $= \frac{R.M}{O.M.} = \frac{54.285}{10.52} = 5.16 > 1.5$

Hence safe

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{7.89}{30.9} = 0.26 < 0.75$

Hence safe

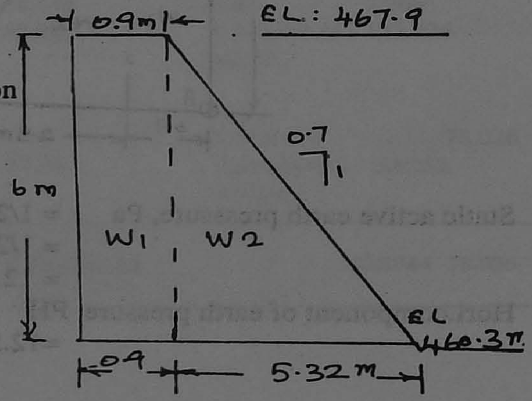
Shear friction factor

$$\frac{0.26 \times 30.9 + 0.5 \times 351.55 \times 3.7}{7.89}$$

$= 83.43 > 5$.

Hence safe

iii) Down stream wing wall: Minimum section (Section `GG')



Static active earth pressure

PA $= 1/2\ wh^2\ Ca$

$= 1/2 \times 2.332 \times 7.6^2 \times 0.6723$

$= 45.278$

Hor.component of earth pressure

PH $= 45.278 \times 0.6293$

$= 28.5$

Vertical com. of earth pressure

Pv = 45.278x0.7771=35.186

Stability check up at EL 460.3M
Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:					
	W1=0.9x7.6x2.3		15.732	0.45	7.080	
	W2=1/2x5.32x7.6x2.3		4.65	0.9+1/3x5.32 = 2.673	124.286	
2.	Earth pressure:					
	Hor.component,PH	28.5		7.6/3=2.533		72.191
	Ver.component Pv		35.186	0.9+2/3x5.32 =4.447	156.471	
	εH =	28.5	εV=97.418		287.838	72.191

εM = 287.838=72.191
= 215.647

χ = εM/εV = 215.647/97.418 = 2.214

eccentricity, e = b/2 ~ χ
= 6.22/2 - 2.214 = 3.11-2.214
= 0.896

6 e/b = 6x0.986/6.22 = 0.864

Max.stress = 97.418/6.22 (1+0.864) = 29.19 t/m² (comp)

Min.stress = 97.418/6.22 (1-0.864) = 2.13 t/m² (comp)

Hence safe

Stability factor = R.M/O.M. = 287.838/72.191 = 3.99>1.5

Hence safe.

Sliding factor = εH/εV = 28.5/97.418 = 0.29<0.75

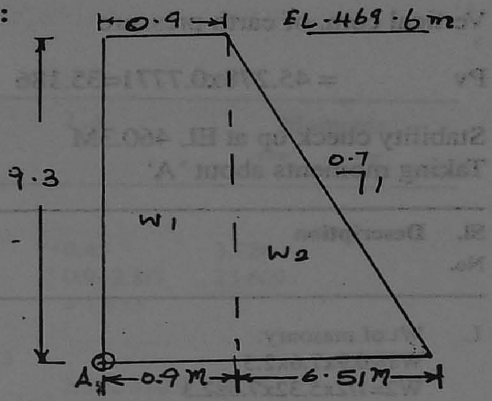
Hence safe

Shear friction factor = (0.29x97.418+0.5x351.55x6.22)/28.5

= 39.4>5.

Hence safe

iv Down stream Wing wall (Maximum section):
(Section `FF')



Static active earth pressure, PA

$= 1/2 \times wh^2\, Ca$

$= 1/2 \times 2.332 \times 9.3^2 \times 0.6723$

$= 67.8$

Hor.component of earth pr.

PH = 67.8x0.6293 = 42.67

Vertical comp. of earth pressure

Pv = 67.8x0.7771 = 52.69

Stability check up at EL 460.3, Taking moments about `A'

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
1.	Wt.of masonry:					
	W_1=0.9x9.3x2.3		19.251	0.45	8.663	
	W_2=1/2x6.51x9.3x2.3		69.624	0.9+6.51/3 =3.07	213.747	
2.	Earth pressure:					
	Hor.component, Ph	42.67		9.3/3=3.1		132.277
	Ver.component, Pv		52.69	0.9+2/2x6.51 =5.24	276.096	
	εH =	42.67	εV = 141.565		498.506	132.277

εM = 366.229

$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{366.229}{141.565} = 2.587$

eccentricity, e $= b/2 \sim \chi = \frac{7.41}{2} - 2.587 = 3.707 - 2.587 = 1.118$

6 e/b $= \frac{6 \times 1.118}{7.41} = 0.905$

Max. stress $= \frac{141.565}{7.41}(1+0.905) = 36.39$ t/m² (comp)

Min. stress $= \frac{141.565}{7.41}(1-0.905) = 1.81$ t/m² (comp) Hence safe.

Stability factor $= \frac{R.M}{O.M.} = \frac{498.506}{132.277.} = 3.769 > 1.5$

Hence safe

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{42.67}{141.565} = 0.3 < 0.75$. Hence safe

Shear friction factor = $\frac{0.3x141.565+0.5x351.55x7.41}{42.67}$

= 31.52>5.

Hence safe

Bibliographical References:

1. Theory and design of Irrigation structures-Vol.I Varshney - Gupta - GUPTA

2. Engg. for Dams - Vol.II - By Creager, Justin & Hinds.

3. I.S.4623-1967 - Recommondations for structural design of radial gates.

4. I.S. 1893-1975 - Criteria for earth quake resistant design of structures.

5. I.S. 6966-1973 - Criteria for hydraulic design of barranges and weirs.

6. CBIP Publication - 4.

7. CBIP Publication - 12.

8. Irrigation manual - By Ellis

Sd/-

For Superintending Engineer,

P.W.D. Designs Circle, Chepauk, Chennai-5.

VANIAR RESERVOIR SCHEME

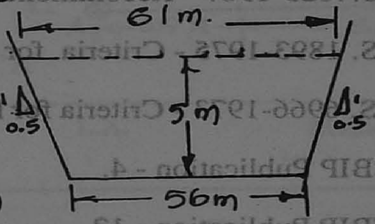
DESIGN OF SURPLUS COURSE AND DROPS

DESIGN OF SURPLUS COURSE:

Max. flood discharge = 654.9m^3/sec(or) 23,120 C/s

Capacity of the head regulator, 709.95 m^3/sec.

The surplus course is to be designed for the max. of the above two values i.e. for 709.95 m^3/sec.



Assumed a bed width of 56m= b

Depth of flow = d = 5.00m

Side slope: 1/2:1 (In cutting & 1:1 1/2 in embankment)

Area of flow: $\frac{(2b+d)}{2} \times d = \frac{(56\times2+5)}{2} \times 5$

$= \frac{117}{2} \times 5 = 58.5\times5 = 292.5m^2 = A$

Bed Fall = S

Velocity of flow = 2.44m/sec 8 ft/sec (in Kankar or S.D.R)

Coefficient of roengosity, n = 0.02 (For discharge x 1000 c/s)

Wetted perimeter, $P = 56+ 5\sqrt{5} = 56+11.18 = 67.18$ m

Hydraulic mean depth, $R = \frac{A}{P} = \frac{292.5}{67.18} = 4.35m$

Velocity of flow as per Mannings Formula.

$V = 1/n \times R^{2/3} \times S^{1/2}$

$= \frac{1}{0.02} \times (4.354)^{2/3} \times S^{1/2}$

i.e. $2.44 = \frac{1}{0.02} \times (4.354)^{2/3} \times S^{1/2}$

i.e. $S^{1/2} = \frac{2.44\times0.02}{(4.354)^{2/3}}$ i.e. $S = \frac{(2.44\times0.02)^2}{(4.354)^{4/3}}$

i.e. $S = \frac{1}{\frac{(1/4.354)^{4/3}}{(0.0488)^2}}$ $\frac{1}{\frac{7.1104}{0.0023814}}$

i.e. $S = \frac{1}{2985.4604}$ or $\frac{1}{12985}$

Q $= A x V = 292.5x2.44$

$= 713.7 M^3/sec$ x $709.95 M^3/sec$

DESIGN OF THE DROPS IN SURPLUS COURSE:
DESIGN OF 4M DROP:

The designed width of surplus course = 56m The same width has been adopted both in the U/S & D/S of drop for surplus course throughout.

The length of the drop wall = 56 m

The design discharge Q = 709.95 m^3/sec

For the max. flood discharge, the depth of flow in the surplus course as per design of surplus course is 5 m. The proposed depth of drop in the surplus course is 4m. i.e. 1M below rear level. The crest body wall will be 1M below the rear water level.

Hence this drop is designed as submergible one. The discharge formula for drowned weir (vide B20 of theory and design of Irrigation Structures Vol.I. By Varshney, Gupta, $Q = 2/3\ cd,$

$L \sqrt{2g} h^{3/2} + Cd_2 . L x d \sqrt{2gh}$

Wher L = Clear waterway i.e. length of drop in this case.

h = difference in water level in U/S & D/S of surplus course in meters.

d = depth of d/s water level in the surplus course above the crest in meters.

g = acceleration due to gravity 9.81 m/sec^2

$cd_1 = 0.577;\ cd_2 = 0.80$

$\therefore 709.95 = 2/3 x 0.577 x \sqrt{2x9.81} x h^{3/2} x 56 + 0.8 x 56 x 1 x \sqrt{2x9.81} x h^{1/2}$

solving 'h' by trial and error method

h = 2.565m for Q = 709.78232m^3/sec which is very near to the design discharge of 709.95m^3/sec.

$\therefore$ h = 2.565m

Total head of flow over crest of drop = h+d

= 2.565+1.00 = 3.565m

ENERGY DISSIPATION ARRANGEMENTS:

The energy is dissipated by means of impact and sudden deflection of velocity from vertical to horizontal direction. A water cushion is provided at the toe of drop to protect the floor

against the impact of falling water and no lessen down the velocity before it leaves the structure.

As per the "Manual an canal falls" issued by central water & Power commission (water wing) the length and depth of water cushion in the case of vertical falls can be fixed by the following relations.

Length of water cushion = $5(H_L x D)^{1/2}$

Depth of water cushion = $1/4(H_L x D)^{2/3}$

Where D = depth of crest below U/S T.E.L. and

H = Height of drop in meters.

Neglecting the velocity of approach = D = 3.565M

$H_L = 2.565$m

Length of water cushion = $5(2.565x3.565)^{1/2} = 15.12$m

∴ Provide a length of 15.5m water cushion

Depth of water cushion = $1/4(H_L x D)^{2/3}$

= $1/4(2.565x3.565)^{2/3} = 1.094$m

Provide a depth of water cushion of 4' (or) 1.20m below the d/s bed level

DESIGN OF DROP BODY WALL:

i) Width at top:

The crest width required for the drop body wall at top

(As per bliglis thumb rule) = $\sqrt{H} + \sqrt{d}$

H = Height of drop body wall in feet = 4.00+1.20=5.20m

d = Depth of flow of water over crest in ft. = 3.565m

= $\sqrt{5.20x3.28} + \sqrt{3.565x3.28}$

= f7.549 ft (or) 2.30m

In this case of sarada type fall for the trapezodial section, the top width required (for discharge above 15 cumecs) is $0.55\sqrt{D+D_1}$. where D = the depth crest below TEL in m. and D_1 = Difference between crest level and D/S bed level in meters.

level in meters as per the "Manual on Canal Falls" (Vide page 14)

Crest width required $= 0.55\sqrt{D+D_1}$

$= 0.55\sqrt{3.565+4} = 1.513$

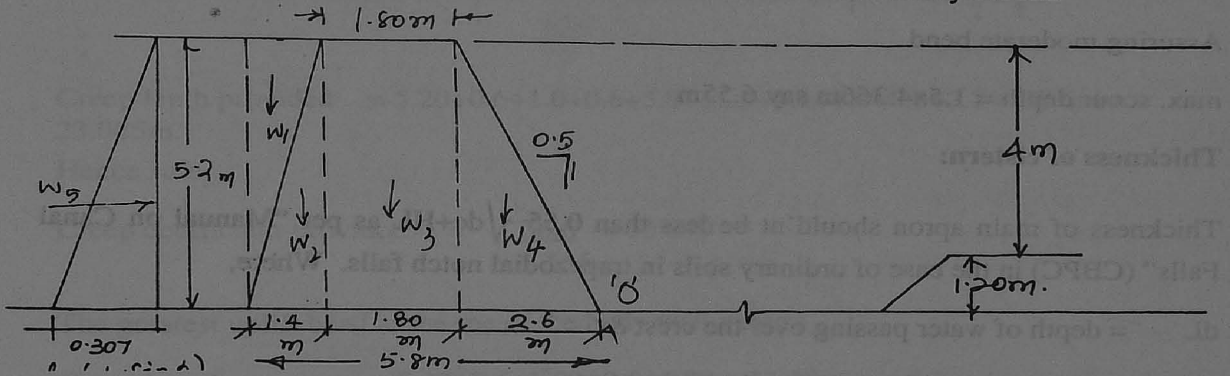
As per the Bliglis thumb rule the crest width required at top is 2.30m and as per the Sarada type (trapezodial profile) the crest width required is 1.513 m. However provide a top width of 1.80m

ii) Width of drop wall at bottom:

The base width of drop wall required at bottom = <u>H+d = 5.20+3.565 = 8.765</u>

$\sqrt{P}$ $\sqrt{2.30}$ 1.517

= 5.78m say 5.80m.



STABILITY ANALYSIS:- EARTH SATURATED NO WATER IS FLOWING OVER THE WEIR

b=5.78m; b/3=1.927m 2b/3=3.85m Vsat = 2.332 t/m³; $\phi = 32^\circ$

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=1/2x1.4x5.2x2.332		8.438	5.333	45.267	
	W_2=1/2x1.4x5.2x2.3		8.372	4.867	40.747	
	W_3=5.2x1.80x2.3		21.528	3.500	75.343	
	W_4=1/2x2.60x5.2x2.3		15.548	1.733	26.945	
	W_5=1/2x2.332x5.2x5.2x0.307	9.679		1.733		16.774
			53.936		188.307	16.774
					εM =	171.533

Distance of resultant from 'O' $= \frac{171.533}{53.936} = 3.180$

The resultant falls within middle third. Hence safe.

It has been found that the drop body wall is safe even in the floating condition i.e. when water is flowing over the weir and the soil is insubmerged condition.

Design of Rear Apron:

Presuming that the surplus course bed contains SDR, Kankar and gravel the Lacey's silt fachor 'F' for medium gravel is 4.75.

Scour depth = $1.35\ (q^2/f)^{1/3}$

Where q = discharge/m run = 12.667678m³/sec

f = 4.75

R = $1.35\ \{(\frac{12.677678}{4.75})^2\}^{1/3} = 4.366$m

Assuring moderate bend

max. scour depth = 1.5x4.366m say 6.55m

Thickness of cistern:

Thickness of main apron should'nt be less than $0.55\sqrt{dc+HL}$ as per "Manual on Canal Falls" (CBPC) in the case of ordinary soils in trapezodial notch falls. Where,

dL = depth of water passing over the crest &

HL = fall in meters (in water levels)

$t = 0.55\sqrt{d_c+H_c}$

$= 0.55\sqrt{3.565+2.565} = 1.361$m

The unbalanced head causing flow = 2.565m

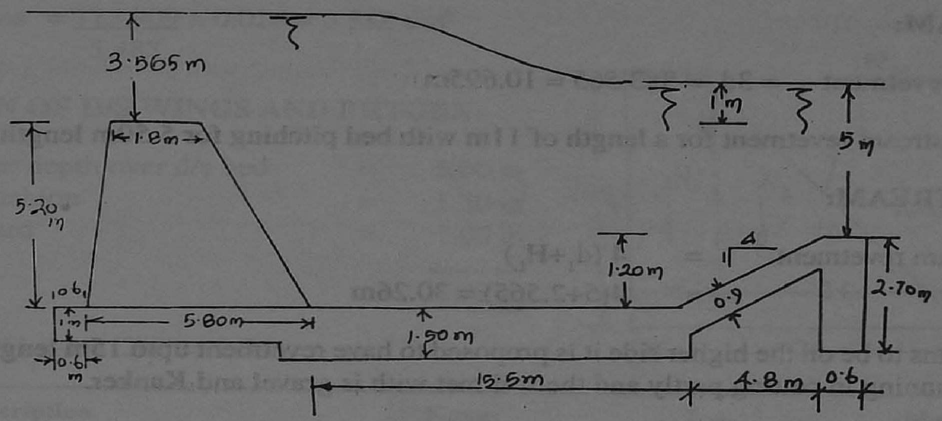
The foundation sub soil as per trial pit particulars & existing soil stratum in well is of Kankar and SDR. As per the bore log particulars furnished by the EE. P.I Dn. Salem in Plan No.SM 28-VM-40 the foundation sub soil is to be taken as Kanker due to the presence of gravelly soil in the core obtained by boring. The values of hydraulic gradient for sand mixed with boulders and shingles may be taken as 1/9 to 1/5 from creep length consideration.

In this case a creep coefficient of 'I' is considered.

∴ The max. creep length required = 9x2.565 = 23.085m

The near cut off depth as per scour = 6.55m from rear water level

However provide the rear cut off in the line with the bottom of rear apron 5+2.70 = 7.70m from rear water level



Creep lenth provided = 5.20+0.6+1.0+0.6+5.8+15.5+4.8+1.8+0.6+2.7 = 38.6m x 23.085m.

Hence safe

Creep coefficient provided = $\frac{38.6}{2.565}$ = 15.049

The greatest uplift bead at the toe of the body wall apron.

Creep length upto toe = 5.20+0.6+1.00+0.6+5.80 = 13.20m.

Balance head at toe = $\frac{2.565}{15.049}$ - 13.2 = 1.688m

Thickness required on uplift consideration = $\frac{1.688}{1.40}$ = 1.205m

However minimum thickness required as per the relation 0.55 ∴d_L+h_L is 1.50m. Hence provide a thickness of 1.50m for the d/s apron. Under body wall a thickness of 1m may be provided.

The difference between the solid apron and the rear bed level is made by gentle slope of 1m 4. For the sloping portion a thickness of 0.9m may be provided.

Revetment and Bed pictching:

In ordinary loomy soils the length of u/s
revetment = 3d, (with minimum of 3m)
The length of d/s revetment = 4 (d_1 + H_L) (with minimum of 6m)

Where d_1= depth of water in the canal above fall
H_L= Fall in meters.
Vide page 14 of 'Manual on canal falls'

The length of bed pitching = 1/2 of the length of revetment.
(vide page 14 of 'Manual on canal falls')

UPSTREAM:

Length of revetment = $3d_1$ = 3x3.565 = 10.695m

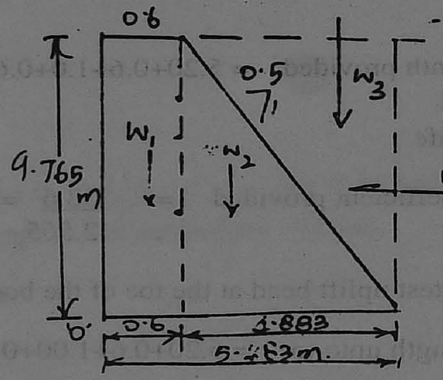
Provide upstream revetment for a length of 11m with bed pitching for 5.50m length.

DOWN STREAM:

Down stream revetment = $4(d_1+H_L)$
= 4(5+2.565) = 30.26m

As this seems to be on the higher side it is proposed to have revetment upto 15m length as the course is running in cutting partly and the soil met with is gravel and Kanker.

Bed pitching is provided for 7.5M length
(i.e. 1/2 of the revetment length)



DESIGN OF ABUTMENT:

Height of drop wall	=	5.20 m
Head over crest	=	3.565 m
Free board	=	1.000 m
Total Height	=	9.765 m

b= 5.483; b/3 = 1.828 2b/3 = 3.656

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=0.6x9.765x2.3		13.476	0.30	4.043	
	W_2=1/2x4.883x9.765x2.3		54.835	2.228	122.172	
	W_3=1/2x4.883x9.765x2.332		55.598	3.855	214.330	
	W_4=1/2x2.332x9.765x9.765x0.307	34.134		3.255		111.106
			123.909		340.545	111.106
					εM = 229.439	

Resultant from 'O' = $\frac{229.439}{123.909}$ = 1.852m

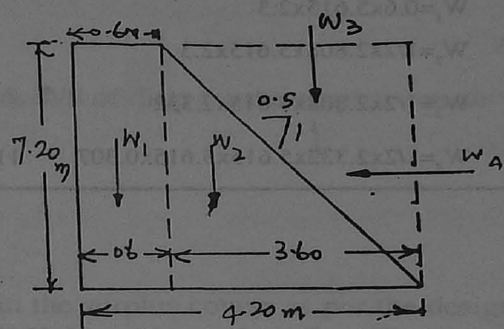
e = 2.742-1.852 = 0.89 ; 6 e/b = 0.974

The resultant falls within middle third. Hence safe.

Max.stress $= \frac{123.909}{5.483} \times 1.974 = 44.61$ t/m^2

Min.stress $= \frac{123.909}{5.483} \times 0.026 = 0.588$ t/m^2

DESIGN OF D/S WINGS AND RETURN:



D/s water depth over d/s bed	=	5.00 m
Water cushion	=	1.20 m
Free board	=	1.00 m
		7.20 m

b = 42 b/3 = 1.4 2b/3 = 2.8m

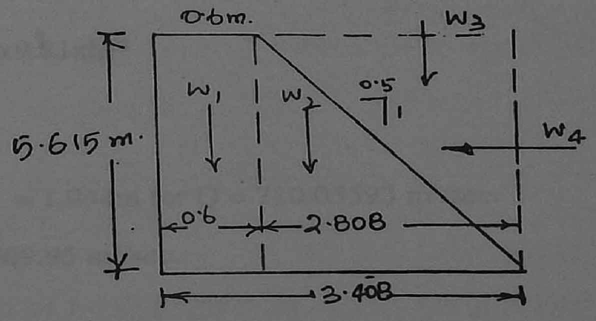
Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W1=0.6x7.20x2.30		9.936	0.30	2.981	
	W2=1/2x3.60x7.20x2.30		29.808	1.80	53.654	
	W3=1/2x3.60x7.20x2.332		30.223	3.00	90.669	
	W4=1/2x2.332x7.2x7.2x0.307	18.557		2.40		44.537
			69.967		147.304	44.537

εM = 102.767

Distance of resultant from 'O' $= \frac{102.767}{69.967} = 1.467$

The resultant falls within middle third. Hence safe.

DESIGN OF D/S WING & RETURN:



Head over crest	=	3.565m
U/s bed bed pitching	=	0.450 m
Clay blanket	=	0.600 m
Free board	=	1.000 m
		5.615 m

b = 3.408; b/3 = 1.136 2b/3 = 2.272

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=0.6x5.615x2.3		7.749	0.30	2.325	
	W_2=1/2x2.808x5.615x2.3		18.132	1.536	27.851	
	W_3=1/2x2.808x5.615x2.332		18.384	2.472	45.445	
	W_4=1/2x2.332x5.615x5.615x0.307	11.286		1.872		21.127
			44.265		75.621	21.127
					εM = 54.494	

Distance of resultant from 'O' = $\frac{54.494}{44.265}$ = 1.231

The resultant falls within middle third value. Hence safe.

Sd/-
for Superintending Engineer,
Design Circle, PWD
Chepauk, Madras - 5.

VANIAR RESERVOIR SCHEME
DESIGN OF DROPS IN THE SURPLUS COURSE:

DESIGN OF 2.0M DROP:

The designed width of surplus course = 56 m

The same width has been adopted both in the U/S & D/S of drop for the surplus course throughout.

Length of drop wall = 56 m

The design discharge = 709.95m³/sec

The maximum depth of flow for 709.95 m³/sec. in the surplus course as per the design of surplus course is 5m. The proposed depth of drop in the surplus course is 5m. The proposed depth of drop in the surplus course is 2m above the rear bed i.e. 3m below rear water level of surplus course. The crest of body wall will be 3m below the rear water level.

Hence the drop is designed as submergible one the discharged formula for drowned weir (vide P220 of theory and designs of irrigation structures by R.S. Vasshney - Gupta - Gupta Vol.I is

$$Q = 2/3\, Cd_1\, L \sqrt{2g}\, h^{3/2} + C2 \times L \times d \times \sqrt{2g}\, h^{1/2}$$

Where L = clear water way i.e. length of drop in this case.

h = difference in water level in U/S & D/S of surplus course in metres.

d = depth of d/s water level in the surplus course above the crest in metre.

g = acceleration due to gravity 9.81 m/sec²

$cd_1 = 0.577$ $cd_2 == 0.80$

$\therefore$ $709.95 = 2/3 \times 0.577 \times 56 \times \sqrt{2 \times 9.81} \times h^{3/2}$

$\& \; 0.8 \times 56 \times 3 \times \sqrt{2 \times 9.81} \times h^{1/2}$

solving for 'h' by trial and error method. h = 1.044m for Q = 710.05593 m³/sec. which is very near to the design discharge of 709.95 m³/sec.

$\therefore$ h = 1.044m

Total head of flow over crest of

drop = h+d = 1.044+3 = 4.044m

Energy dissipation arrangements:

The energy is dissipated by means of impact and sudden deflection of velocity from vertical to horizontal direction. A water cushion is provided at the toe of drop to protect the floor against the impact of falling water and to lessen down the velocity before it leaves the structure.

As per the "Manual on canal falls" issued by central water & power commission (water wing) the length and depth of water cushion in the case of vertical falls can be fixed by the following relations.

Length of water cushion = $5(H_L xD)^{1/2}$

Depth of water cushion = $1/2(H_L xD)^{2/3}$

Where D = Depth of crest below U/S T.E.L. &

HL = Height of drop in metres

Neglecting the velocity of approach = D = 4.044

HL = 1.044m

length of water cushion = $5(1.044x4.044)^{1/2}$

= 10.274m

Provide a length of 10.5m water cushion

Depth of water cushion = $1/4(H_L xD)^{2/3}$

= $1/4(1.044x4.044)^{2/3} = 0.653$m

Provide a depth of 0.75m water cushion below the down stream bed level of the surplus course.

SCOUR DEPTH: The scour depth in the D/S of solid apron as calculated for 4m drop (vide the design of 4m drop) is 6.55 m for moderate bend in the surplus course.

The required depth of D/S cut off wall

= 6.55-5.00 = 1.55m

However 2.05m depth of d/s cut off wall is provided so as to be in line with the bottom level of the apron.

DESIGN OF DROP BODY WALL:

(i) Width at top:

The crest width required for the drop body wall at top (As per bliglis thumb rule) $\sqrt{H} + \sqrt{d}$

Where H = Height of drop body wall in ft = 2.00+0.75 = 2.75 m
d = depth of flow of water overf crest in feet = 4.044m

$= \sqrt{2.75x3.28} + \sqrt{4.044x3.28}$

$= 3.00+3.16 = 6.64$ ft (or) 2.02m

In the case of sarada type fall for the trapezoidal section the top width required (for disharge above 15 cumec) is $0.55 \sqrt{D+D_1}$ Where D = the depth of crest below T.E.L and D_1 = difference between crest level and d/s bed level in metres as per the manual on canal falls (vide P 14)

Crest width required $= 0.55 \sqrt{D+D_1}$

$= 0.55 \sqrt{4.044+2} = 1.352$ m

In this case

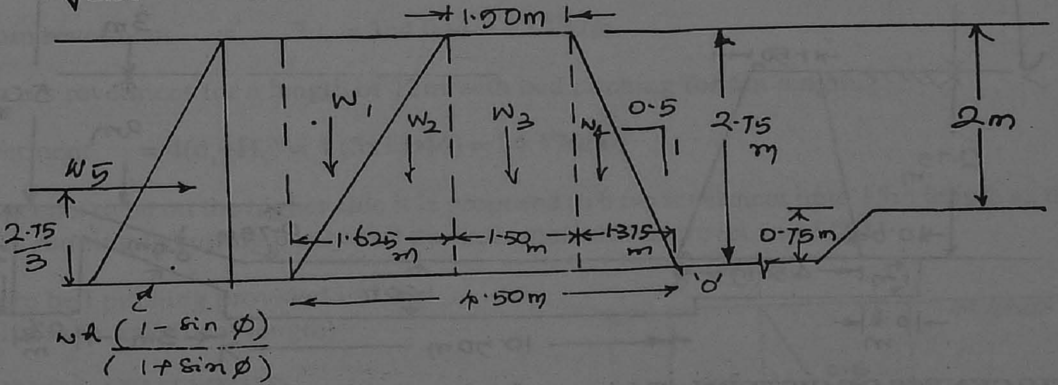
$D = 4.044m; D_1 = 2m$

As per the Bliglis thumb rule the crest width required at top is 2.02m and as per the Sarada type (trapezoidal profile) the crest width is required is 1.352m. However provide a top width of 1.50m

(ii) Width at Bottom:

The base width of drop wall required is

$\frac{H+d}{\sqrt{P}} = \frac{2.75+4.044}{\sqrt{2.30}} = \frac{6.794}{1.517} = 4.478$ say 4.50m



SRABILITY ANALYSIS:

Condition : Earth saturated. No water is passing over weir $\phi = 32°$
vSat = 2332 kg/m³

b = 4.50m b/3 = 1.50m 2b/3 = 3m.

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=1/2x1.625x2.15x2.332		5.211	3.958	20.625	
	W_2=1/2x1.625x2.75x2.30		5.14	3.417	17.563	
	W_3=1.50x2.75x2.30		9.488	2.125	20.162	
	W_4=1/2x1.375x2.75x2.30		4.343	0.917	3.987	
	W_5=1/2x2.332x2.75x2.75x0.307	2.707		0.917		2.482
			24.187		62.337	2.482
				ƐM =	59.855	

L.A. = $\frac{59.855}{24.187}$ = 2.475m

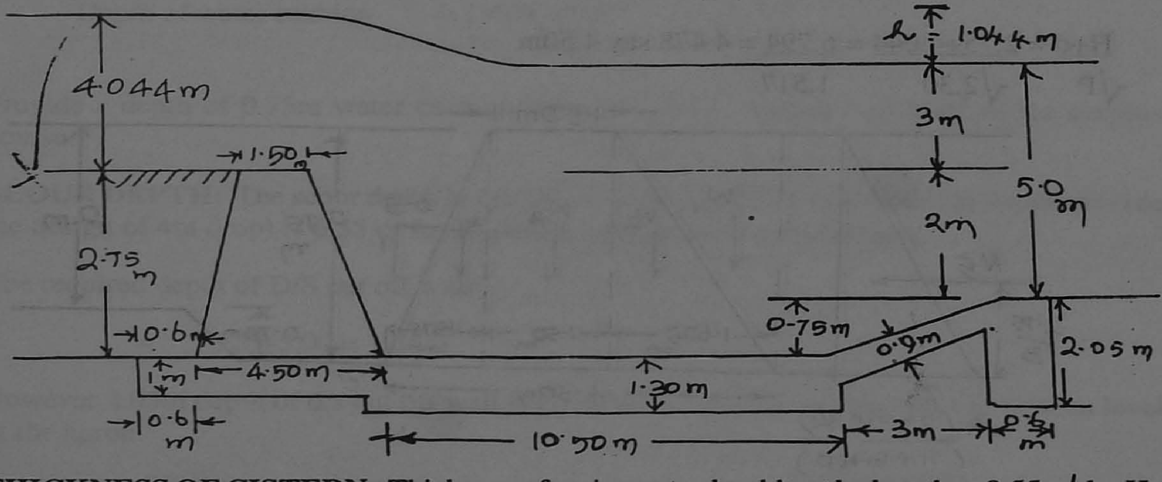
The resultant falls within middle third. Hence safe.

DESIGN OF REAR APRON:

Adopting the creep coefficient of '9' as detailed in the design of 4m drop for this design of two meter drop.

The unbalanced head causing flow = 1.044m

∴ The minimum creep length required = 1.044x9 = 9.39m



THICKNESS OF CISTERN: Thickness of main apron should not be less than $0.55\sqrt{d_c+H_L}$, where d_c = depth of water passing over the crest; HL = fall in meters (in water level) as per "Manual on canal falls" in the case of ordinary soils in trapezoidal notch falls.

In this case dc = 4.044 ; HL = 1.044

t ∴ t = $0.55\sqrt{4.044+1.044}$ = 1.24m

Creep length provided (vide sketch)
= 2.75+0.60+1.00+0.6+4.5+10.50+3.0+1.15+0.6+2.05 = 26.75m x 9.396

Hence creep length provided is safe.
Creep coefficient provided = $\frac{26.75}{1.044} = 25.625$

The greatest uplift head on the D/S toe of the body wall:

Creep length upto toe = 2.75+0.6+1+0.6+4.5 = 9.45 m

Residual head at toe = $1.044 - \frac{9.45}{25.623}$

= 1.044-0.369 = 0.675m

∴ Thickness required on uplift consideration = $\frac{0.675}{1.40} = 0.482m$

However minimum thickness required as per the relation $0.55 \sqrt{d_c+H_L}$ is 1.24m

Hence provide a thickness of 1.30m for the d/s apron. Under body wall a thickness of 1m may be provided the difference between the solid apron and the rear bed level is made by gentle counter slope of 1in 4 for the sloping portion a thickness of 0.90m may be proided.

REVETMENT & BED PITCHING:

In ordinary loomy soils the length of U/S revetment = $3d_1$ (with minimum of 3m). The length of d/s revetment = $4(d_1+H_L)$ (with min. of 6m) where d_1 = depth of water in the canal above fall H_L = fall in meters. (vide P 14 of "Manual on canal falls"). The length of bed pitching = 1/2 the length of revetment.

Upstream revetment = $3d_1 = 3x4.044 = 12.132m$

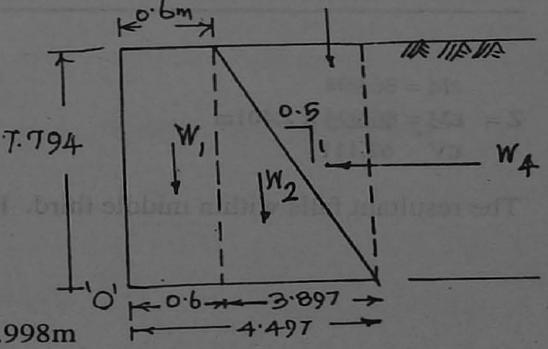
Provide u/s revetment for a length of 12m with bed pitching for 6m length.

D/s revetment = $4(d_1+H_L) = 4\ (5x1.044) = 24.176m$

As this seems to be on the higher side it is proposed to have revetment upto 15m length as the course is running in cutting partly and the soils met with is gravel and SDR.

Therefore bed pitching provided is 7.5m
(i.e. half of the revetment length)

DESIGN OF ABUTMENT:



Height of drop wall	=	2.75m
Head over crest	=	4.044m
Free board	=	1.00m
		7.794m

b/2 = 2.249m b = 4.497; b/3 = 1.499m; 2b/3 = 2.998m

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=0.6x7.79x2.30		10.756	0.30	3.227	
	W_2=1/2x3.897x7.794x2.3		34.93	1.899	66.332	
	W_3=1/2x3.897x7.794x2.332		35.415	3.198	113.257	
	W_4=1/2x2.332x7.79x7.794x0.307	21.745	-	2.598		56.494
			81.101		182.816	56.494

εM = 126.322

Z (Resultant position) $= \frac{126.322}{81.101} = 1.558$

e = 2.2485-1.558 = 0.691; 6 e/b = 0.922

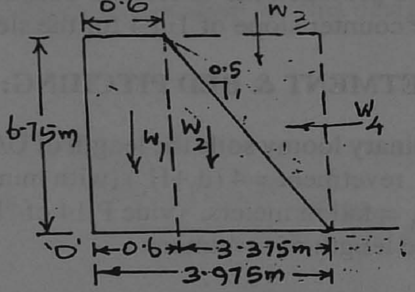
The resultant falls within middle third. Hence safe.

Max. stress $= \frac{81.101}{4.497} \times 1.922 = 34.66$ HM²

Min. stress $= \frac{81.101}{4.497} \times 0.078 = 1.41$ HM²

DESIGN OF D/S WINGS AND RETURN:

D/S water depth over D/S bed	=	5.00m
Water cushion	=	0.75m
Free board	=	1.00m
Height of wings & return	=	6.75m



b = 3.975; b/3 = 1.325; 2b/3 = 2.65 b/2 = 1.988

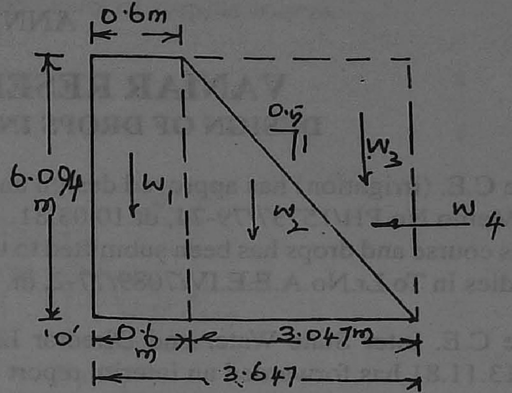
Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=0.6x6.75x2.3		9.315	0.30	2.795	
	W_2=1/2x3.375x6.75x2.3		26.198	1.725	45.192	
	W_3=1/2x3.375x6.75x2.332		26.563	2.850	75.705	
	W_4=1/2x2.332x6.75x6.75x0.307	16.31		2.25		36.698
			62.111		123.692	36.698

εM = 86.994

$Z = \frac{\varepsilon M}{\varepsilon V} = \frac{86.994}{62.111} = 1.401$m

The resultant falls within middle third. Hence safe.

DESIGN OF U/S WINGS AND RETURNS:



Head over crest	=	4.044m
U/S Bed pitching	=	0.450m
Clay blanket	=	0.600m
Free board	=	<u>1.000m</u>
		<u>6.094m</u>

b = 3.647; b/3 = 1.216; 2b/3 = 2.432

Sl. No.	Description	Forces H	Forces V	L.A.	Moments +ve	Moments -ve
	W_1=0.6x6.094x2.30		8.410	0.30	2.523	
	W_2=1/2x3.047x6.094x2.30		21.354	1.616	34.508	
	W_3=1/2x3.047x6.094x2.332		21.651	2.631	56.964	
	W_4=1/2x2.332x6.094x0.307	13.294		2.031		27.000
			51.415		93.995	27.000
					εM =	6.995

$$Z(\text{Resultant Position}) = \frac{66.995}{51.415} = 1.303$$

The resultant falls within middle third. Hence safe.

Sd/-
For Superintending Engineer,
Designs Circle, PWD
Chepauk, Chennai-5.

ANNEXURE

VANIAR RESERVOIR PROJECT

DESIGN OF DROPS IN THE SURPLUS COURSE

The C.E. (irrigation) has approved design and drawings for the surplus course and 2m drops in Memo No.PH/15737/79-74, dt.10.03.81. The approved designs and drawings of the surplus course and drops has been submitted to the Director I.H.H. Poondi for conducting model studies in To Lr.No.A.E.E.IV/7089/77-2, dt.12.03.81.

The C.E. Inter State Water and Director I.H.H. Poondi in Lr.No.TA/STD/RD 5416-1/81 dt.13.11.81 has forwarded an interim report No.1 on the model studies for Vaniar Reservoir Project salient points in the I.H.H. Poondi Report are as follows:

1. Uniform flow at constant depth cannot be obtained when we have hydraulic drops with crest and flow depth will fall much below the normal depth and approach the critical depth and higher velocities developed below the first drop were getting cumulatively increased along the course leading to super critical flow in the channel.

2. The design of the drops has been improved with broad crest and also with crest wall over the surplus course bed. The proposals of the drop have been finalised at I.H.H. Poondi after trying in models services of alternatic dimensions for the crest width and the crest wall depth. Crest width of body wall = 2.50 m (recommended).

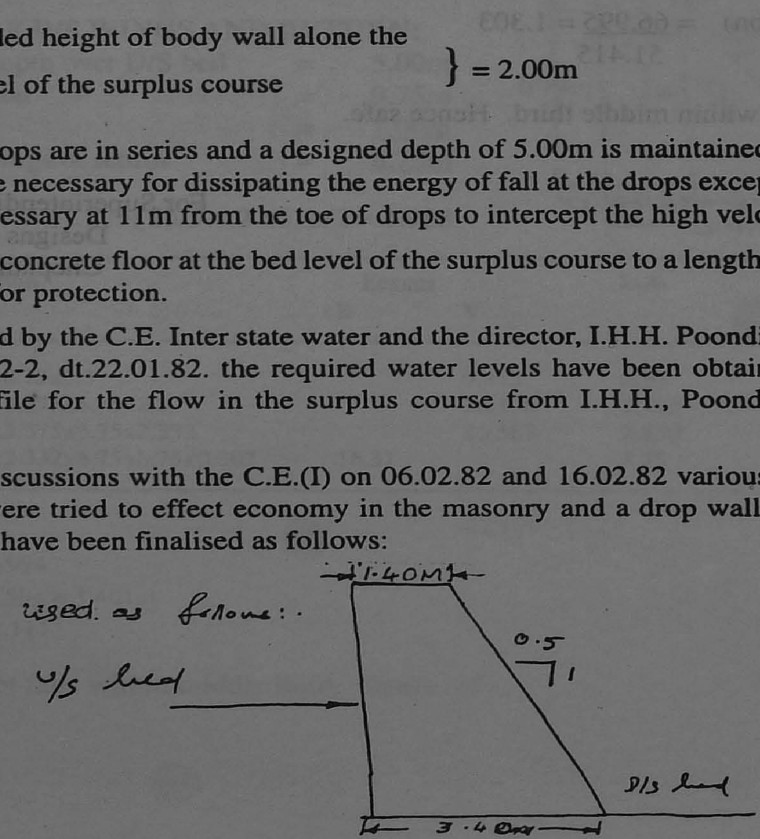
Recommended height of body wall alone the U/S bed level of the surplus course } = 2.00m

3. As the drops are in series and a designed depth of 5.00m is maintained, no water cushion is seem to be necessary for dissipating the energy of fall at the drops except that 0.50m baffle is found necessary at 11m from the toe of drops to intercept the high velocity bed filament.

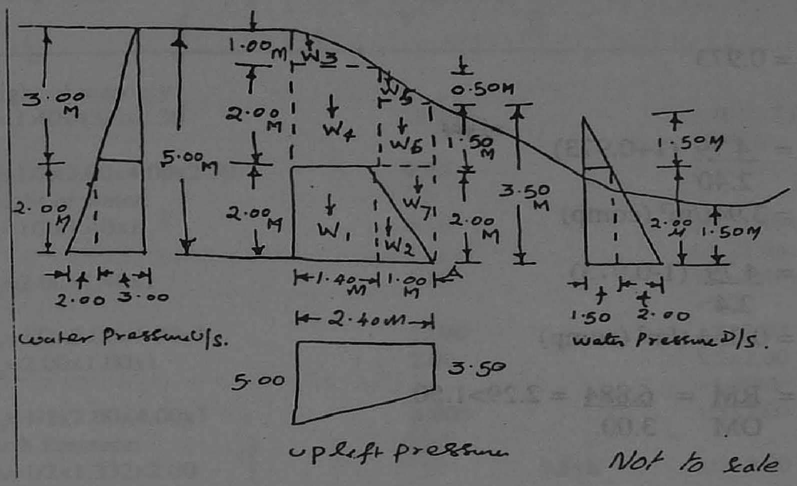
4. A simple concrete floor at the bed level of the surplus course to a length of 15m will all that is required for protection.

As suggested by the C.E. Inter state water and the director, I.H.H. Poondi in Lr.No.TA/STO/R05416-1/82-2, dt.22.01.82. the required water levels have been obtained from the water surface profile for the flow in the surplus course from I.H.H., Poondi, Drg. No.132/82, dt.22.01.82.

Based on discussions with the C.E.(I) on 06.02.82 and 16.02.82 various alternatives of the drop wall were tried to effect economy in the masonry and a drop wall with the following dimensions have been finalised as follows:



Checking the stability of the drop wall at U/S bed level of surplus course.



Sl. No.	Description	Forces V	H	L.A.	Moments +ve	-ve
1.	Weight of masonry:					
	W_1=1.40x2.00x2.30	6.440		1.4/2+1.0 =1.70m	10.948	
	W_2=1/2x1.00x2.00x2.30	2.30		2/3x1.00	1.533	
2.	Weight of water:					
	W_3=1/2x1.40x1.00x1	0.70		2/3x1.40+1.00 =1.933	1.353	
	W_4=1.40x2.00x1	2.80		1.40+1.00 =1.70	4.760	
	W_5=1/2x1.00x0.50	0.25		2/3x1.00	0.167	
	W_6=1.00x1.50x1	1.50		1/2=0.50m	0.75	
	W_7=1/2x1.00x2.00x1	1.00		1/3m	0.333	
3.	Water Pressure:					
	3.00x2.00x1		6.000	1/2x2.00 = 1.00m		6.000
	1/2x2.00x2.00x1		2.00	1/3x2.00		1.333
	1.50x2.00x1		(-)3.000	1/2x2.00 =1.00m		(-)3.000
	1/2x2.00x2.00x1		(-)2.000	1/3x2.00		(-)1.333
4.	Uplift + Pressure:					
	2.40x3.50x1	(-)8.400		2.4/2=1.20m	(-)0.080	
	1/2x1.40x2.40x1	(-)1.800		2/3x2.40	(-)2.880	
		4.790	3.000		6.884	3.000

$\varepsilon M = 3.884 mt$

$$\chi = \frac{\varepsilon M}{V} = \frac{3.884}{4.79} = 0.811$$

e = h/2-χ
= 2.4/2-0.811
= 0.389 m

$\frac{6e}{b} = \frac{6 \times 0.389}{2.40} = 0.973$

Maximum stress = $\frac{4.79}{2.40}$ (1+0.973)
= 3.94t/m² (comp)

Minimum stress = $\frac{4.79}{2.4}$ (1-0.973)
= 0.054 t/m² (comp)

Stability factor = $\frac{RM}{OM} = \frac{6.884}{3.00.} = 2.29>1.50$

Hence safe.

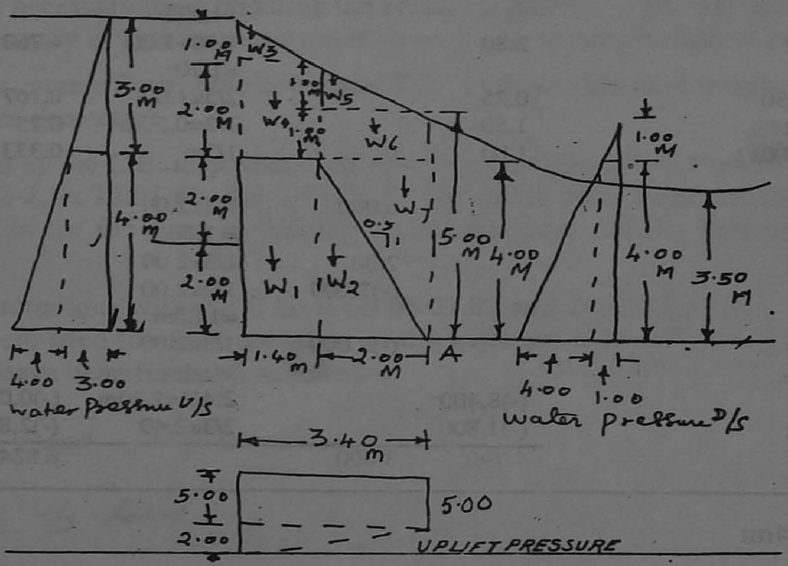
Sliding factor = $\frac{\varepsilon H}{\varepsilon V} = \frac{3.00}{4.79.} = 0.626<0.75$

Hence safe.

Shear friction factor = $\frac{0.626 \times 4.79+0.5 \times 351.55 \times 2.40}{3.00}$
= 141.62>5.

Hence safe.

Checking the stability of the drop wall at D/S bed level of surplus course.



Taking moments about A

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Weight of masonry:					
	W_1=1.40x4.00x2.30	12.880		1.40/2+2.00 =2.70M	34.776	
	W_2=1/2x2.00x4.00x2.30	9.20		2/3x20	12.267	
2.	Weight of water:					
	W_3=1/2x1.40x1	0.70		2/3x1.40+2.00 =2.933m	2.053	
	W_4=2.00x1.40x1	2.80		1/2x1.40+2.00 =2.70	7.560	
	W_5=1/2x2.00x1.00x1	1.000		2/3x2.00	1.333	
	W_6=2.00x1.00x1	2.00		1/2x2.00 =1.00M	2.000	
	W_7=1/2x2.00x4.00x1	4.000		1/3x2.00	2.667	
3.	Earth Pressure:					
	PA=1/2x1.332x2.00 $\left(\frac{1-\sin 32^o}{1+\sin 32^o}\right)$		0.818	1/3x2.00		0.546
4.	Water pressure					
	3.00x4.00x1		12.000	1/2x4.00		24.000
	1/2x4.00x4.00x1		8.000	1/3x4.00		10.667
	1.00x4.00x1		(-)4.000	1/2x4.00		(-)8.000
	1/2x4.00x4.00x1		(-)8.000	1/3x4.00		(-)18.667
5.	Uplift pressure					
	5.00x3.40x1	(-)17.00		1/2x3.40	(-)28.90	
	1/2x3.40x2.00x1	(-)3.40		2/3x3.40	(-)7.707	
		12.180	8.818		26.049	16.546

$$\varepsilon M = 9.503 \text{ mt.}$$

$$\chi = \frac{\varepsilon M}{\varepsilon V} = \frac{9.503}{12.18} = 0.78$$

Eccentricity 'e'
$$= \frac{b}{2} - \chi$$
$$= 3.40/2 - 0.78$$
$$= 1.70-0.78 = 0.92\text{m}$$

$$\frac{6e}{b} = \frac{6x0.92}{3.40} = 1.624\text{m}$$

Max.stress
$$= \frac{12.18}{3.40}(1+1.624)$$
$$= 9.40 \text{ t/m}^2 \text{ (comp)}$$

Min. stress
$$= \frac{12.18}{3.40}(1-1.624)$$
$$= (-)2.235 \text{t/m}^2 \text{ (Tension)}$$

Stability factor $= \frac{RM}{OM} = \frac{26.049}{16.549} = 1.574 > 1.50$

which is slightly above the min. value.

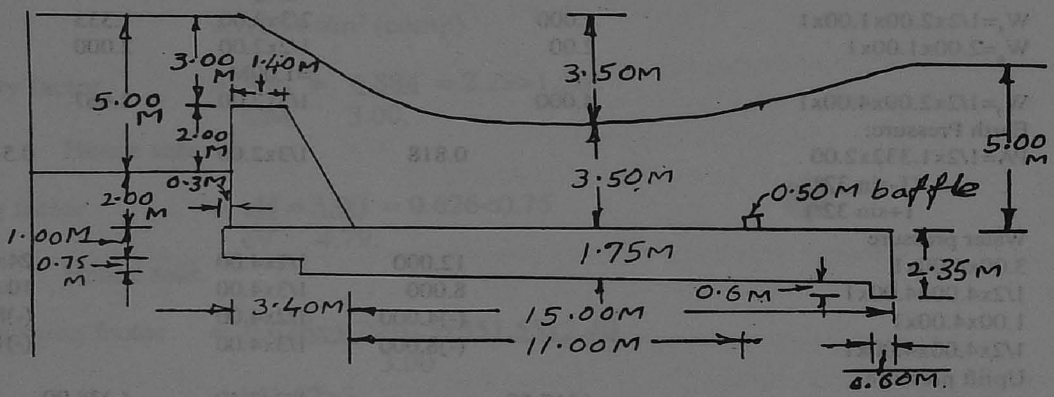
Hence safe.

Sliding factor $= \frac{\varepsilon H}{\varepsilon V} = \frac{8.818}{12.18} = 0.724 < 0.75$

Shear friction factor $= \frac{0.724 \times 12.18 + 0.5 \times 351.55 \times 3.40}{8.818}$

$= 68.77 > 5$

Hence safe.



The surplus course bed contains Kankar and gravel. The Lacey's silt factor 'f' for medium gravel is 4.75

Scour depth, R $= 1.35 \left(\frac{q^2}{f}\right)^{1/3}$

where q = discharge per meter run

f = Lacey's silt factor

R $= 1.35 \left\{\frac{(12.267)^2}{4.75}\right\}^{1/3}$

R = 4.35M

Assuming moderate bed,

maximum scour depth = 1.50xR

= 1.50x4.35 = 6.525M

The required depth of D/S cut off wall = 6.525-5.000

= 1.525M

Assuming a thickness of 1.75m for down stream apron which is below the scour depth and also a thickness of 1.00M under the body wall, no separate cut off is provided. However as suggested by the Director IHH Poondi in Lr.No.TA/STO/R05416-1/82-2, dt.22.01.82, a retaining wall of size 0.60M x 0.60M has been proposed at the end of the floor.

The foundation sub soil as per the trial pit particulars and existing soil stratum in well i.e. of Kankar and soft disintegrated rock. The values of hydraulic gradient for sand mixed with boulders and shingles may be taken as 1/9 to 1/5 from creep length consideration.

Creep length provided = 2.00+0.30+1.00+0.30+3.40+0.75+15.00+0.60+2.35
= 25.70M

For the creep length provided creep coefficient } $= \frac{25.70}{3.50} = 7.343$

which is between 5 and 9 and may be allowed.

Creep length upto toe of body wall = 2.00+0.30+1.00+0.30+3.40+0.75
= 7.75M

Residual head at toe of drop wall $= 3.50 - \frac{7.75}{7.343}$
= 2.445M

Thickness required on uplift consideration $= \frac{2.445}{1.40} = 1.746M$

Hence the thickness already provided for main rear apron (1.75M) is safe against uplift consideration. Under the body wall a thickness of 1m of foundation concrete is proposed.

As per page 14 of "Manual on canal falls"

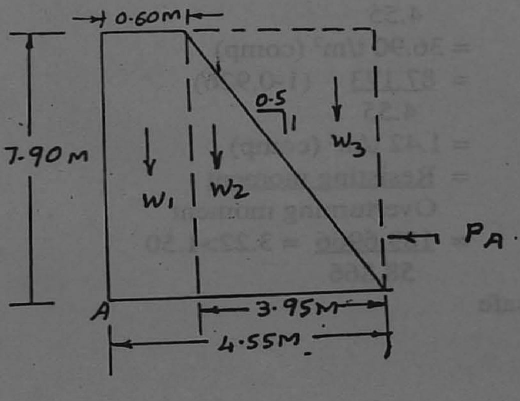
Length of upstream revetment = 3d, where
d = depth of water in the canal above the fall.
Length of bed pitching = 1/2xthe length of revetment.
Length upstream revetment = 3x5 = 15.00M

Provide U/S revetment for a legnth of 15.00 M with bed pitching for 7.50M length.

Length of D/S revetment = $4 (d_1+H_L)$
where d_1 = depth of water in the canal above the fall.
H_L = fall of water level.
Length of D/S. revetment = 4(5.00+2.00)
= 28.00M

Provide D/S revetment for a length of 28.00 m with a bed pitching for 14 m length.

Design of abutment section.



Height of drop wall		= 4.00M
Depth of flow over dropwall		= 3.00M
Free board		= 0.90M
Total height		= 4.00+3.00+0.90
		= 7.90M

Earth pressure $= PA = 1/2\ wh^2 \dfrac{(1-\sin\phi)}{(1+\sin\phi)}$

$= 1/2 \times 2.332 \times 7.90^2 \dfrac{(1-\sin 32^o)}{(1+\sin 32^o)}$

= 22.354 t/m run

Stability check up at foundation level:

Taking moments about 'A'

Sl. No.	Description	Forces V	Forces H	L.A.	Moments +ve	Moments -ve
1.	Weight of masonry					
	W_1=7.90x0.60x2.30	10.902		0.30	3.2706	
	W_2=1/2x3.95x7.90x2.30	35.886		0.60+1/3x3.95 = 1.9167	68.7810	
2.	Weight of earth					
	W_3=1/2x3.95x7.90x2.332	36.383		0.60+2/3x3.95 = 3.233M	117.645	
3.	Earth pressure PA		22.354	1/3x7.90		58.866
		83.173	22.354		189.6966	58.866

$\varepsilon M = 130.8306mt.$

$\chi = \dfrac{\varepsilon M}{\varepsilon V} = \dfrac{130.8306}{83.173} = 1.573M$

Eccentricity e $= \dfrac{b}{2} - \chi$

$= 4.55/2 - 1.573 = 0.702m$

$\dfrac{6e}{b} = \dfrac{6x0.702}{4.55} = 0.926$

Maximum stress $= \dfrac{87.173}{4.55}(1+0.926)$

$= 36.90\ t/m^2$ (comp)

Minimum stress $= \dfrac{87.173}{4.55}(1-0.926)$

$= 1.42\ t/m^2$ (comp)

Stability factor $= \dfrac{\text{Resisting moment}}{\text{Overturning moment}}$

$= \dfrac{189.6966}{58.866} = 3.22>1.50$

Hence safe

Sliding factor $= \frac{\varepsilon H}{\varepsilon V}$

$= \frac{22.354}{83.173} = 0.269 < 0.75$

Hence safe.

Shear friction factor $= \frac{0.269 \times 83.173 + 0.5 \times 351.55 \times 4.55}{22.354}$

$= 36.78 > 5$

Hence safe.

Sd/-

For Superintending Engineer,
Designs Circle, P.W.D.
Chepauk, Chennai -5.

VANIAR RESERVOIR PROJECT

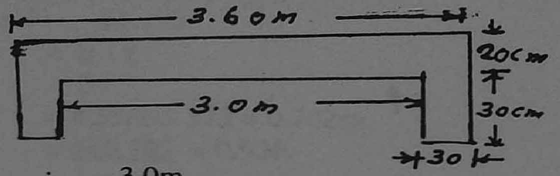
Design of Approach Bridge for the Left and and right side irrigation sluices at L.s. 735 M and L.S. 1310M·

General: For both the sluices, there are 5 spans of 8.60m each, first span resting on jack arrangements over the earth dam and the fifth span resting on the 0.9m thick masonry of the dry well. There are four intermediate braced column taken from the top of the collar for the sluice barrel cast monolithic with the R.C.C. connecting end beam.

Data: The loading particulars obtained from the TAPWEC in Lr.No.A.E(D)/1837/79, dt.01.09.80 are as follows.

Weight of emergency gate (7'x8)'	:	7.5 t
Weight of Trolly	:	0.5 t
Gauge distance	:	0.65 m
Axie to Axle distance	:	0.54m
Clear minimum road width	:	3.60m
No. of spans	:	5 nos.
Span c/c of column/supports	:	8.60m
Top of deck slab	:	Eℓ.474.00m
Top of conc. collar	:	Eℓ.454.70m
Size of collar	:	1.0x1.40m

Design of deck slab



Clear Span : 3.0m

As the deck slab and the L - beam are to be monolithic.

Effective Span : 3.0m (vide cl.21.2 b. I of I.S. 456-78)

Load : 20 cm

Dead Load : structural conc-20x25 = 500 kg/m²

funishes 75

Live Load: (UDL)

(vide cl 3.1.1 of I.s. 875.1964 = 400 kg/m²

(or) the gate trolly weight (moving load)

1. S.S. moment due to U.D.D.L.-575x3²/8 = 647.00 kg
2. S.S. moment due to U.D.L.L.-400x3²/8 = 450.00 kg
3. S.S. moment due to gate trolly wt.

Total load = 7.5+0.5 = 8.0t

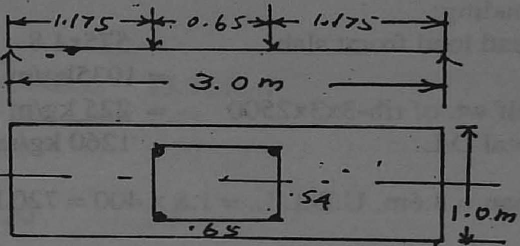
Land/Wheel = 8/4 = 2.0t

Max.S.S.B.M. = 4(1.5-0.325)

= 4.7 t.m

= 4700 m.kg.

Fixed end moments:



due to U.D.D.L.-575x3²/12

= 431 m.kg

due to U.D.L.L.-400x3²/12

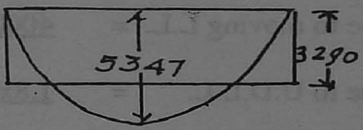
= 300 m.kg

Trolly load - $\frac{4x1.175\ (3-1.175)}{3}$ = 2.859 t.m

= 2859 m.kg.

While considering the trolly load, the U.D.L.L. need not be considered since at a particular point both cannot act simultaneously.

Hence max.+ve & -ve B.M. at mid span and support section are obtained by superinposing both



max.S.S.B.M. = 647+4700

= 5347 mkg.

max. FEM = 431+2859=3290m.kg

Net max. + B.M. at mid span = 2057 m.kg

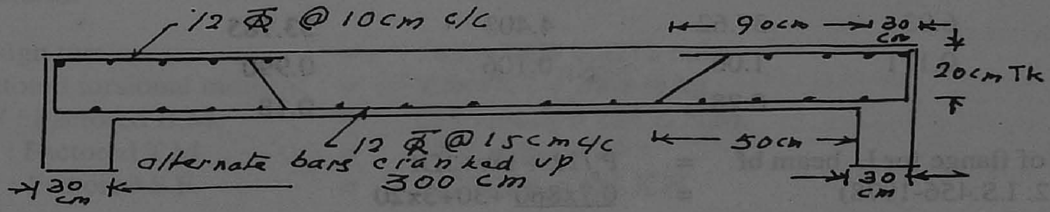
Max-B.M. at support = 3290 m.kg.

Impact factor = $\frac{4.5}{6+L}$ = $\frac{4.5}{6+3}$ = 0.5

As the D.L. is comparatively small as compared to moving L.L. the imfact factor is applied for the total B.M. Thus, design moments are + = 1.5x2057 = 3086 mkg

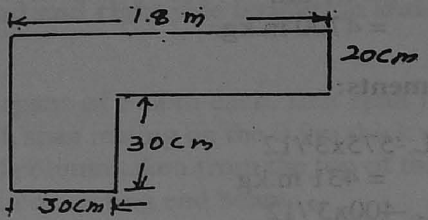
- = 1.5x3290 = 4935 mkg.

Details	**+B.M.**	**-B.M.**
M	3086	4935
Mu	4629	7403
For b = 100cm		
d = 18 cm		
K = mg/bd²	14.30	22.8
100 pt	0.372	0.643
Ast	6.7cm²	11.57 cm²
Rft	12@15cm C/C	12@10cm C/C
Distributories	20cm C/C	B@20cm C/C



DETAILS OF DECK SLAB

Design of L. Beams:

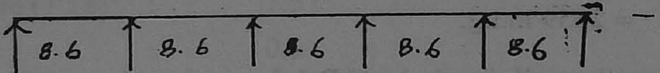


Loading:

Dead load fromt slab	=	575x1.8
	=	1035kg/m
Self wt. of rib-3x3x2500	=	225 kg/m
Total D.L.		1260 kg/m

Span = 8.6m, U.D.L.L. = 1.8 x 400 = 720 kg/m

The beam is analysed as continuous over intermediate supports and simply supported end span.



Live load: Reaction from the trolly load from slab
= 400 kg on the middle 'I'm length of span.

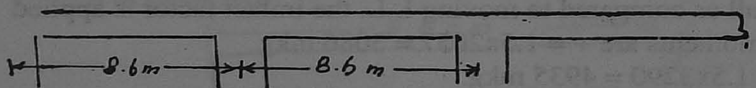
1) FEM due to D.L. = $\frac{1260x8.6^2}{12}$ = 77.66 m.kg

2) FEM due to moving L.L. = $\frac{4000x(3x8.6^2-1^2)}{24x8.6}$ = 4281m.kg

3) FEM due to U.D.L.L. = $\frac{1.8x400x8.6^2}{12}$ = 4438 m.kg

As the FEM due to UDLL is greater it is considered for design purposes in addition to D.L.

DESIGN FOR BEND IN MOMENT:



(vide table 7.0 I.S. 456-1978

D.L.coeff	+1/12	-1/10	+1/24	-1/12
D.L.	1260kg/m			
D.L.M.	+7766	-9319	+3883	-7766
L.L.coeff	+1/10	-1/9	+1/12	-1/9
L.L.	720kg/m			
L.L.M.	+5325	-5917	+4438	-5917
Total m.	+13091	-15236	+8321	-13683
Ma	19637	22854	12482	20525
K	6.93	37.62	4.403	33.785
100pt	0.171	1.06	0.106	0.990
100psc	-	0.28	-	0.18

(Breath of flange for L. beam bf = $P_o/12$ + bw+3Df
(d.22.1.2. I.S.456-1978) = $\frac{0.7x860}{12}$ +30+3x20

= bf = 140 cm

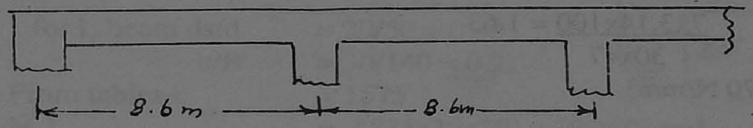
D = 50cm, d = 45 cm

For +B.M. bfd^2 = 283500

For-B.M. b = 30 cm; d = 45 bd^2 = 60750

Ast	10.773cm²	14.31cm	14.452cm²	13.365cm²
ASC	-	3.78cm²	-	2.43
Top Rft	2.20	6.20	2.20	5.20
Bottom	4.20	2.20	3.20	2.2

DESIGN FOR SHEAR FORCE:



D.L. coeff	0.40	0.60/0.55	0.50
1. D.L.S.F.	4334	6502/5960	5418
2. L.L.Coeff	0.45	0.60/0.60	0.60
L.L.S.F.	2786	3715/3715	3715
3. Moving L.L	4000	4000/4000	4000

As the S.F. due to moving LL ie trolly load is greater it is combined with that the U.D.D.L. for max. shear consideration.

Design shear force 8334kg 10502kg 9418kg

Max. factored shear force = 1.5x10502 = 15753 kg

TORSIONAL MOMENT:

1. Due to UDDL of slab - $\frac{431 \times 8.6}{2}$ = 1853 m.kg
2. Due to UDLL of slab - $\frac{300 \times 8.6}{2}$ = 1290 m.kg
3. Due to trolly load -2859 m.kg.

As the torsional moment due to trolly load is greater it is combined with the tension due to U.D.D.L.

Design torsion	=	1853+2859 = 4712 m.kg
Factored torsional moment	=	1.5x4712 = 7068 m.kg
MV : Factored B.M.	=	22854m.kg = 224 K.N.M.
TV : Factored T.M.	=	7068 m.kg. = 69 "
VV : Factored S.F.	=	15753 kg. = 154 K.N.

For L - beam b = 140 cm
d = 45 cm

Equivalent shear V_e = $V+1.6(t/b)$

$= 154 + \frac{(1.6 \times 69.0)}{1.4} = 233$ K.N.

Equivalent shear stress C_{Ve} = $\frac{Ve}{Dd} = \frac{233 \times 10^3}{30 \times 45 \times 10^2}$

$= 1.725 N/MM^2$

< Allowable tc max for M15 conc is $2.5 N/MM^2$
Hence the section does not required revision.

At this section P_t provided = $\frac{7 \times 3.14 \times 100}{30 \times 47} = 1.63$

For this P_t tc from table 61 is $0.70 N/mm^2$

< tve = $1.72 N/mm^2$
Hence longitudinal & transverse reinforcement are to be designed.

Equivalent B.M.M_{el} = $M_v + Mt$

$= M_v + T \frac{(1+D/b)}{1.7}$

$= 224 + 69 \frac{\left(1+\frac{50}{30}\right)}{1.7}$

$= 332.21$ K.N.M.

$\frac{M_v}{bd^2} = \frac{332.2 \times 10^6}{140 \times 45^2 \times 10^3} = 1.117 N/mm^2$

Referring to table 1, for this $P_t = 0.362$

AST = $\frac{0.362 \times 140 \times 45}{100} = 22.806 cm^2$

Provide TNOS-20 on flexunel tensile force

As M_t is $< M_{v1}$, M_{e2} need not be considered. On the compresion face the steel provided for mid span shall be continued after suitable cranking.

As the depth of beam is > 45 cm (50cm)

Side face right $= \frac{0.05 \times 30 \times 47}{100} = 0.71 cm^2$

proide 2nos. 12 are each per face

Transverse reinforcement should satisfy the following.

ASV1 $\frac{t_u S_u}{b_1 d_1 (0.87fy)} + \frac{V_u S_u}{2.5 d_1 (0.87fy)}$

$$0.87 f_g \, ASU = \frac{T_u}{b_1 d_1} + \frac{V_u}{2.5 d_1} = \frac{69 \times 10^6}{44 \times 25 \times 10^3} + \frac{154 \times 10^3}{2.5 \times 44 \times 10}$$

= 202.7 N/MM

= 2.027 K.N./CM

Steel w.r.t web area $= \frac{7 \times 3.14 \times 100}{30 \times 45} = 1.63$

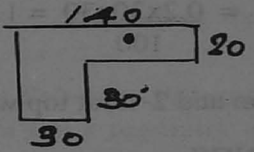
Corresponding tc from to be = 0.69 N/mm²

(tve-tc)b = (1.77-0.61) 30x 10

= 306 N/MM = 3.06 K.N/CM

For this 3.06 K.N./CM shear per cm run refering to table 62_1 provide 2L @ 11cm C/C

DESIGN OF COLUMNS:



1 for L beam ds/d = 20/50 = 0.40

b/B = 30/140 = 0.21

From tables-c = 1575

M.I. $= .1575 \times 30 \times 50^3 = 590625 \text{ cm}^4$

$= 59 \times 10^4 \text{ cm}^4$

I for column 30x40 cm - $1/12 \times 30 \times 40^3 = 160000 \text{ cm}^4$

Height of column =	474.00
from top of deck to bottom of footing	454.70
	19.30m

Total unsupported height excluding deck slab and footing = 18m say

height of column $= \frac{10.0}{4} = 2.5\text{m}$

I/ℓ for column $= \frac{16 \times 10^4}{450} = 356$

I/P for beam $= \frac{59 \times 10^4}{860} = 687$

ε I/ℓ = 1730

D.F. for column $= \frac{356}{1730} = 0.21$

D.F. for beam $= \frac{687}{1730} = 0.40$

Unbalanced moment due to L.L. = 4438 mkg

Column moment = 21x4438 = 932 m.kg

column load = 2xbeam S.F. = 2x10502 =21004 kg

Self Wt = 3x4x18x2500 = 5400 kg

Selft wt of braces .3x.3x2500x3x8.6 = 5805 kg

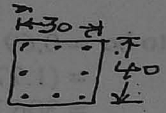
32209 kg

or 33000kg

P = 33000kg m = 932 m.kg

p_u = 49500kg m_u = 1378 m.kg

$P_u = \dfrac{49500}{150x30x40}$ = 0.275 $Mu = \dfrac{1398x100}{150x30x40^2}$ = 0.0194



Refering to chepter 44 = P/fck = 0
Provide minimum steel = .8/100x30x40 = 9.6cm²
Provide 4 Nos. - 20
Laterals 6 Nos.@25cm C/C

The bracings shall be 30x30 cm size reinforced with nominal steel = $\dfrac{0.2x30x30}{100}$ = 1.8cm²

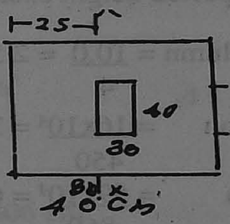
provide 2 - 12 at bottom and 2-12 at top with 2L 6Nos. stirrups @ 20 cm C/C.

DESIGN OF FOOTINGS:

Column load = 32209 kg
Self wt of sooting = 3221 kg
35,430 kg (or) say 36t

As the column footing is proposed to be resting on the R.R. masonry collar around the sluice barrel, taking the JBC of R.R. as 8 of/m², area required = 36/80 = 0.45 m²
However provide a sie of footing 80x80cm

Net upward pressure = $\dfrac{32209}{80^2}$ = 5.03 kg/cm²



Max. = 5.03x25x80x25/2
= 125750 cm.kg

M_u = 188625 cm.kg

$\dfrac{MU}{bd^2} = \dfrac{188625}{40x30^2}$ = 5.24

From Tables, P_t = 0.1275

Ast = $\dfrac{0.127x40x30}{100}$ = 1.724 cm²

Min.steel = $\dfrac{0.2x40x30}{100}$ = 2.4cm²

Provide 8mm 9 Nos. both ways

Min.steel = $\dfrac{0.2}{100}$ x 40 x 80 = 6.4

Spacing = 9 CM C/C Nos.9

Sd/-
For Superintepnding Engineer, P.W.D.
Designs Circle, Chennai-5.

ANNEXURE

(PUBLIC WORKS DEPARTMENT)

From

Thiru C.F.Martis, B.E.,
Superintending Engineers, PWD
Designs Circle
Chepauk, Chennai-5.

To

The Executive Engineer, PWD
Project Investigation Division
Salem - 4

Lr.No.AE.IV/7089/77/dt.29.08.77.

Sir,

Sub : Mullikadu Village - Vaniar Reservoir Scheme - Alternate proposal for surplus course at right flank - design of right flank regulator and surplus course - regarding.

Ref :
1. This Office Lr.No.AE.IV/7089/77/dt.05.08.77.
2. Exe.Engr.P.I.Divn. Salem-4, Lr.No.Camp No.2, Harur dt.15.08.77.
3. This Office Lr.No.AE.IV/7089/77, dt.22.08.77.

In the reference first cited above the Executive Engineer Project Investigation Division, Salem has sent field particulars for the Vaniar Reservoir Scheme and requested this office to furnish the design of right flank surplus regulator with surplus course. The Exe.Engr. has not furnished all the data and field particulars which are required for taking up the design of flank regulator. The details of particulars that are wanting, have been called for from the Exe.Engr. in this office letter third cited above which are awaited.

However in view of urgency, the design of right flank surplus regulator with surplus course have been takenup and completed in this office based on the following assumptions.

1. The details of bore leg particulars along the alignment of the regulator and adjacent to the regulator site on the downstreams and upstreams are not furnished. In the drawing showing the L.S. of the dam alignment from the centre of the river to the right flanks regulator tentative rock level has been assumed by the Exe.Engr. and indicated without any basis. Based on this, the rock level is assumed as + 451.00 at the proposed regulator site. Thee rock level have to got to be confirmed by the Exe.Engr. by puting bore holes and bore log particulars furnished to this office.

2. A surplus course of 720m. length is proposed by the Exe. Engr. to negotiate the total, drop of 9m, in the bed fall itself without introducing any drops. As per this proposal, the bed slope comes to 1/80 which is too and the velocity developed will be more than that the bed material can safely carry.

In this office, the length of the surplus course is shortened to 365m. with the introduction of two drops of 4.65m. by taking the surplus course in an alternative alignment to economise on the cost of the surplus course. The revised alignment is based on the levels furnished by the Executive Engineer in the drawing showing the site survey of the surplus

course at right flank. The Exe.Engr. has furnished trial pit particulars upto 0.5m. depth only along the surplus course and that two at two sections only which is quite inadequate.

It is seen that S.D.R. is met with in the surplus course, as per the trial pit particulars furnished

It is assumed that SDR will be met with even along the proposed alternate alignment of the surplus course. The permissible velocity allowed in the SDR in the surplus course is 3m/sec.

The tentative design and drawing prepared in this office for the surplus regulator, surplus course and drops, based on the above assumptions are herewith enclosed. After the entire field data are furnished to this office it has to be checked up whether the tontative design now prepared will suit to the actual site conditions.

The design and drawing of the flank regulator and surplus course and drops will have to be revised if there is any change in the assumptions made referred to above.

The earth typical section for this scheme could not be finalised for want of soil parameters. The Exe.Engr. is requested to report whether the fresh soil samples have been sent to Executive Engineer, Soil Mechanics and Research division for conducting tests and to furnish soil parameters to this office.

The necesssity for having a right flank surplus arrangement with surplus course may be reported to this office as an alternative to the left flank regulator as already proposed.

Sd/-
Superintending Engineer, PWD
Designs Circle, Madras-5.

Encl: Design Vol.II
Drawing - 3 Nos.
(Design we will be sent separately)

Copy to The Superintending Engineer, PWD Investigation Circle
Trichy-20 with enclosures.

Copy submitted to
The Chief Engineer (Investigation) Chepauk,
Madras - 5 with enclosures.

Sd/-
For Superintending Engineer, PWD
Designs Circle, Madras - 5.

ANNEXURE

Thiru C.N.Margam, B.E.
Superintending Engineer, PWD

Designs Circle, Chepauk
Madras - 5.

D.O.Lr.No. AEE.IV/7089/77, dated.18.07.80.

My Dear Rajarathinam

Sub: Stage of designs regarding Vaniyar Reservoir Project - Reg.

Ref: Your telephonic discussions on 15.07.80.

In continuation of the telephonic discussion, Mr.Oliver Daniel, Assistant Engineer of the Chief Engineer (Irrgn.) Office met me and gave me the details of pendency as made out in your office. I am discussing the same in serietum.

1. Revised drawing of surplus regulator after attending to the remarks pointed out.

Stage: The remarks had already been attended and was ready for resubmission for approval by the Chief Engineer (Irrigation). In the meanwhile, the Special Superintending Engineer, Krishnagiri had in his Lr.No.208M/AE(2)/80, dt.02.07.80 had mentioned, the shifting of the regulator site to LS 340 from LS 267.25 on grounds of considrable savings in the outlay especially in earth work excavation. As it is a question of economising the proposal, the fresh details given by the field Superintending Engineer has been taken into account and the designs have been formulated. It is currently under check and it will be furnished to the Chief Engineer by about 25th of the July 1980, on the presumption the revised location will be approved by the Chief Engineer on grounds of economy.

2. Revised design and drawing of drops and alignment of surplus course.

Stage: Once again, the field Superintending Engineer, in his letter cited in the foregoing para had favoured dispensing with the combined structue of cut-off wall cum-2 M drop based on this office analysis furnished to him together with the merits and demerits of the proposition. Now, the plan indicates in the surplus course furnished along with the reference cited, give certain changer which require to be incorporated in the final proposals to be submitted to the Chief Engineer (Irrigation) and this entails sometimes. I shall be forwarding the designs and the necessary proposals during the last week of July 1980.

3. Design and drawing of irrigation sluice.

Stage: Pending results of the load bearing tests, with estimated data, the designs have been completed and the proposals will be furnished to the Chief Engineer in a complete shape by the end of second week of August.

4. Typical sections of earth dam.

Stage: The typical sections of earth dam have been completed and are under tracing and will be furnished shortly.

5. Stability analysis on earth dam for the 10 ft. height of additional storage over present FRL proposed.

Stage: As mentioned, the details have been only received on 14.01.80 through the Special Superintending Engineer letter to the Chief Engineer (I) wherein he has dealt on the merits and demerits of the proposals. The Chief Engineer (Irrigation) orders are awaited for going on with this work. Already, the probable reflection in the quantum of earth work involved has been outlined in the foregoing para and in case, 10 ft. raise is to be agreed to, the question of tackling the regulator has been outlined as proposals 1 and 2 vide this office Lr.No.AEE.IV/7089/77, dt.14.07.80. Early orders of the Chief Engineer may be obtained and communicated for taking up the work on the same.

Summing up, the proposals as contemplated at present will be given in a complete shape by the end of first week of August. In case, the 10 ft. is conceded to, the works have to be done, performance reanalysed, denove and dresh proposals and designs have to be formulated.

With Kind regards,

Yours sincerely,

(C.M. Margam)

To

Thiru L.Rajarathinam, B.E., M.E.
Sr. Deputy Chief Engineer, PWD.
(Irrigation)
Chepauk, Madras - 5.

CHAPTER 24
COMMISSIONING AND MAINTENANCE

24.1 The Vaniar Reservoir Project work was commenced in June, 1979 and was physically completed in February 1985. The inaugural function was held on 3.3.1985 and the canals were opened for irrigation that day. The conservation of water in the reservoir and its operation are done to meet the irrigation demands only.

24.2 DISTRIBUTION SYSTEM

The old command of 796.03 ha (1967 acres of wet crops) is supplied by four channels taking off from 4 (four) anicuts situated one after another in the river below the dam. These channels fed the ayacut directly and also through 5 (five) tanks indirectly. The distribution network is as follows:

	Sl. No.	Name of Anicut/Tank (Acres)	Extent Capacity (M.Cft.)	Tank
I.		**Venkatasamudram Anicut**		
	1.	Venkatasamudram Direct Channel	128.99	-
	2.	Venkatasamudram Tank	342.91	9.75
II.		**Alapuram Anicut**		
	1.	Alapuram Direct Channel	202.04	-
	2.	Alapuram Tank	542.40	36.24
	3.	Ondhiampatti Tank	36.00	3.15
	4.	Thenkaraikottai Tank	79.00	8.84
III.		**Elumichai Perumal Koil Anicut**		
	1.	E.P.Koil Anicut Direct Channel;	185.80	-
	2.	Parayappatti Tank	283.00	10.61
IV.		**Kanakkan Anicut System**	166.86	-
			1967.00	

Water required of old command is calculated at a duty of 25 acres per million Cubic Feet (M.Cft). This is led into the river by means of a connecting channel which takes off at 50 m from the right main canal through a small regulator-cum-diversion arrangement. This channel has a limited capacity of 52 cusecs only and joins the river immediately below the toe of the dam.

The new command consists of 3460ha. (8550 area) of irrigated dry crops. It is served by two main canals - viz. Left Main Canal and Right Main

Canal taking off from Vaniar Reservoir. The left main canal feeds 1630 ha. (4050 acres) in its run of 19.40 km through 5 (five) branches and 78 Direct Irrigation (D.I>) sluices. The right main canal feeds 1821 ha. (4500 acres) in its run of 12.74 km through 3 (three) branches and 69 D.I. sluices. Cross masonry works are built at all necessary places for easy transport and passing down drainage. The details are furnished in the Annexure.

The main and branch canals are lined with cement concrete slabs. Water courses have been excavated upto 10 ha. limit. These are left unlined.

The main canals and the distributaries are generally in good condition except in some places where the precast slabs are missing and bed lining disturbed. Tampering of sluices are noticed here and there. There is no drainage problems to be tackled in Vaniar command.

The anicuts are in fairly good condition indicating fair maintenance. The supply channels taking off from these anicuts are covered with shrubs and vegetation. Sluices in these channels feeding the direct ayacut are in damaged condition here and there. The paddle shutters fitted to them are either in bad shape or altogether missing. Some time irrigation is done illegally by cutting open bunds of these supply channels and cross bunding to the detriment of the lower down interests. The screw-gearing shutters in the Venkatasamudram anicut and the one in the third weir of Alapuram Tank which feeds Ondhiyampatti Tank are tampered with. The supply channel to this Ondhiampatti Tank which takes off from the left flank end of Alapuram Tank is filled with muck and overgrown with vegetation. And its carrying capacity is therefore considerably reduced at present.

On perusal of revenue records, it is stated that the last anicut - viz., Kanakkan Anicut does not seem to have any Registered Ayacut. But it has a command area of 67.6 ha. (166.86 acres). This system was repaired and restored in the early seventies under special Minor Irrigation Programme. It appears that the localisation of ayacut under this anicut supply system has not yet been completed.

The anicut is in good shape now. There are some minor patches of damage to the apron floor down stream. Earth is found removed in a haphazard fashion in front of the anicut main body wall. The supply channel off-taking from the right has an under tunnel immediately afterwards. The silt removal arrangement is not effective. The scour vent is built on the other (left) end. The channel is in a fair condition only for a short distance from its head. The rest of the supply system is in disrepair due to continued neglect of maintenance over the past many years.

On general the old system is in a serviceable condition as far as its head works and channels for a short distance after their off-takes are concerned. The age old set up has not materially changed. Its maintenance on a participative arrangement which prevailed before is not in existence now.

24.3 CULTIVATION STATISTICS

The following cultivation statistics for the fasli years 1398 to 1404 for the old command have been collected from the Revenue Department. The average cultivation is 421.71 hectares against the registered extent of 796.03 hectares. The cultivation is poor as it works out to 59.46%. The water use efficiency is very low. It is worked out and shown later that with Vaniar supplementation and yield from its own catchment, two crops could have been cultivated. An abstract of the cultivation statistics is as given below:

Fasli Year	Registered Extent (ha.)	Cultivated Extent (ha.)	Water allowed through Sluice ($M.m^3$)
1398(88-89)	796.03	646.800	2.845
1399		409.840	3.702
1400		499.110	1.775
1401		531.880	5.524
1402		397.425	2.382
1403		412.770	2.200
1404(94-95)		411.170	2.858
	Total	**3308.995**	
	Average	**472.71**	

Note : 1406 fasli corresponds to the current year 1996-97.

Average quantity of water allowed for the old command works out to 3.12 M.cum. against scheme estimate provision of 2.23 m.cum. at a duty of 25 acres/M.cft.

24.4 New command has been proposed in the scheme estimate as irrigated dry in 3460 hectares (8550 acres). But wet crops are raised in more than 50% of the command. Cultivation statistics, have been collected for fasli years from 1396 to 1404. A statement showing the village-wise, fasli-wise cultivation statistics is enclosed separately. An abstract of the cultivation statistics is as given below:

NEW COMMAND

Fasli	Registered Extent (ha.)	Cultivated Extent (ha.) Wet	Dry	Total	Water Allowed for New Command (M.M³)
1396	3460	467.800	144.64	612.674	6.877
1397		83.115	88.610	171.725	8.977
1398		140.400	83.275	223.675	9.499
1399		57.720	46.855	104.575	4.784
1400		30.575	36.215	66.790	1.391
1401		180.760	237.880	418.640	9.435
1402		155.355	190.125	305.480	10.448
1403		163.195	170.420	333.615	11.268
1404		194.330	149.965	344.295	13.417
		1433.250			**76.096**

Average cultivation : 159.250 ha. wet and 127.58 ha. dry.

It is worth while to review these cultivation statements. The comments are as follows:

24.4.1 According to the operation and maintenance staff of PWD, the revenue statistics given above do not reflect a realistic picture of agricultural out puts in the ayacut areas. The revenue authorities appear to take into account only the lands which are irrigated by the canals continuously through-out a crop period and altogether neglect the extents which received partial irrigation and used water from wells to bring the crops to maturity and harvest. The cropped areas benefited by the wells with in the command also appeared to have been excluded.

A theme that was stressed in every scheme report and write-ups on this project was that the waters of V.R.P. stored and distributed will indirectly rise the ground water level in the surrounding areas. The wells in the ayacut do get recharged to a great extent when the canals are run for the irrigation. The following passage confirms that the revenue officials shared and did agree with their indirect benefit theory.

Extracts from Collector Dharmapuri letter No.ROC 5461/73-A, dt.02.03.75. in recommending the proposal of reservoir across Vaniar received from Executive Engineer Project Investigation Division, Salem in E.E's letter No.ROC 11823/67-1 dt. 29.01.73. run as follows "though uneconomical, the

scheme has grow more food value. The people are anxious and the backward area of Harur has to be improved. There are number of wells in the ayacut area. The project canals will go up; hence there will be additional food production by way of one more crop. The project may be viewed from the point of view of overall strategy and be included in the 5th Plan D.P.A.P. project for Dharmapuri District so that its implementation is expedited"

When this had been their stand point in the sanction of this scheme it is strange that while presenting the cultivation statistics, serious attempts are not made to include the areas benefitted by wells in the command. A blind cultivations statistics as above need not therefore be considered to represent the performance efficiency to the project.

24.5 Existing conditions of the infrastructure : Head works

Vaniar Reservoir is the first irrigation structure across the river and it is situated at the foot of the Sherveroyan hills. Siltation studies have not been carried out since its formation in 1985. There is no cultivation in the foreshore. Its small catchment is hilly and covered with vegetations. Chances of catchment erosion and land slips are remote. Hence there may not be any appreciable accumulations of silt in the reservoir bed leading to loss of capacity. However, it is advisable to carry out silt surveys as soon as possible so as to establish the present capacity and also to determine the future useful life of the scheme.

The dam and appurtenant works are in good condition. The embankment is free from settlements; No bulging of alignments or sloughing is noticed anywhere. Rain erosions on the downstream slopes are quite minimum. The longitudinal collector drains along the berms are filled with earth. Some growth of vegetations are noticed in the toe drain. These may be easily removed. No damages to revetments, rock toes and filters and parapets are seen. The electric cables to the lamp posts on the right flank and shades and lamps are found missing. It appears that this vandalism has place only recently.

Seepage water through the earth dam is reported to be clear always so far during all the seasons. The flow rate increases with the water level elevations in the reservoir. The results reproduced are for one typical year. The quantity of seepage through the two deep sections of the earth dam may appear to be little excessive.

No cracks or slides; signs of movements or settlements nor any surface cracks are noticed in any of the masonries of surplus regulator, the two tower head sluices and the various drops in the surplus course. No duct or drainage tunnel is provided in the body wall of the surplus regulator. Hence no leaching observations are possible. Weep holes in the abutment wings are functioning normally. No unusual stains are seen in the wall surfaces. Aprons are in good condition.

Gates and hoist equipment are maintained in good condition. Standby generator, wire ropes and operating sets etc. are in serviceable order. No corrosion or spitting are seen in the gate leaves. Water seals around the sluice gates however, need attention. The maintenance staff say that the sill beams of the canal head sluices are to be lightly machined before fitting the new seals. At present leakages occur through these sluice vents under fully closed conditions.

24.5.1 FLOOD DAMAGES

All the drops are generally in good condition. The dam has not experienced significant floods so far. There are no damages to the body walls, wing walls and apron floors anywhere. But the revetment slopes along either sides of the surplus course - which are rather too steeply built at 1/2 to 1 slope have given way in many places. A drainage in fall on the left side which had collapsed before had been restored with the addition of a masonry cistern. The slipped revetments were not attended to . Slope correction and usage of heavier stones will be found necessary. Random rubble in cement mortar protection walls on either side of the river course immediately after the confluence of the surplus course with it for a fairly long distance have been constructed recently to safeguard the lands situated close by the river margins here. Apart from these minor additions no other improvements are done at the head works nor there is any necessity for it.

24.6. CURRENT OPERATING PROCEDURES - IRRIGATION SCHEDULES

As per the scheme Report, water is allowed for the new command at a duty of 14 acres/M.Cft. Irrigation season is from first day of September to last day of December.

Draft Rules of Regulation in respect of Vaniar Reservoir is yet to be approved by the Government.

Synopsis of the draft Rules of Regulation is given below:

Control

Regulation of supply of the Reservoir shall be the responsibility of the Assistant Engineer/Junior Engineer in charge of the Reservoir (who shall hereafter be called the controlling officer under the overall direction of the assistant Executive Engineer.

Impounding

Entire flow at the Reservoir site can be impounded for the benefit of new and old commands.

Impounding in the Reservoir shall be done as per the rate of increase in water level elevations as given below:

Upto the level of +466.500 M no limit

Between +466.500 m to 470.400 m not more than 0.60 m per day.

Between +470.400 m to 471.000 m not more than 0.30 m per day.

Impounding shall not be done above the level of 470.400 m. (i.e. 0.60 m below FRL) during the monsoon period i.e. October to December. At the fag end of the north-east monsoon i.e. in the month of December when the floods are likely to recede, the reservoir can be brought to FRL.

NEW IRRIGATION

Supply for the new command for raising dry crops will be allowed normally from first of September to 31st of December

A minimum level of +468.300m corresponding to the storage of 323.83 M.cft. is necessary in the reservoir to allow water for the entire new command so that the supply can be maintained till the onset of north-east monsoon, i.e. 15th of October.

If the storage is not adequate for allowing supply for the entire ayacut under the canal system, for Executive Engineer in charge, in consultation with the Collector of Dharmapuri District shall fix the extent that can be supplied and probable date from which supply could be made and give wide publicity to it not later than middle of August.

The command area under each canal is divided into two zones of more or less equal area. The supply will be effected for five days for a depth of 6 cm (21/2 inches). The first zone in left main canal and right main canal will receive water for 5 days and the second zone will receive water for the next 5 days. Supply will be stopped for the next 5 days for both the zones. Then the first zone will receive water for 5 days on the 16th day and so on.

As per the project report, water will be released to the old command to a limit of 78.68 M.cft. (this is, 25 acres/M.cft. for 1967 acres). This quantum of water is the legitimate right for the old command. Supply for new command will be considered only after meeting the requirement of old command as mentioned above.

For the old command, 50 cusecs. of water will be released on first of September till the tanks are filled. Further requirement for the old command will be allowed down the river through the diversion arrangement in the right main canal immediately after its off take from the main tower head sluice upto the legitimate demand of 78.68 M.cft.

Normally the reservoir will be opened for irrigation on the first of September and will be continued till December. The reservoir is to be opened with the concurrence of the Collector, Dharmapuri after the views of the Agriculture Department are obtained. Any modification required in the opening of

the canals and the schedule for irrigation due to poor storage, has to be done by the Executive Engineer in charge and such schedules should be got published for the information of the ryots in the District Gazette.

NEW COMMAND - IRRIGATION PATTERN - TURN SYSTEM

Sl. No.	Name of Canal	First Zone Reach	Command in acres	Discharge in cusecs.	Second Zone Reach	Command in acres	Discharge in cusecs.
1.	Right Main Canal	L.S. 0 to 4.600 km & branch canals	2030.19	44.77	L.S.4,600 to Tail Dam (12.40 km)	2469.81	14.47
2.	Left Main Canal	L.S.0 to 10.150 km & all its branch canals except branch canal IV	2023.20	44.63	L.S.10.150km to Tail Dam Branch Canal IV	2026.80	44.70

GENERAL (FLOOD REGULATIONS)

Notwithstanding these rules, if in the opinion of the controlling officer depletion of part of entire storage is considered necessary in the interest of the safety of the dam he may do so after full consideration of all relevant factors and after giving prior intimation to all PWD staff concerned and Collector of Dharmapuri for ordering and taking such precautionary measures as necessary and also facilitate utilisation of the released storage.

i) Whenever any deviation of these rules is considered necessary in the interest of irrigation, prior approval of the Chief Engineer (Irrigation) or his nominee viz., the Superintending Engineer, in charge of Vaniar Dam should be obtained after fully explaining the necessity therefor.

ii) The regulation shall normally be done once a day at 8.00 A.M.. and shall be based on full appreciation of all relevant factors.

However, during floods, regulation may be done at such frequent intervals as may be necessary to ensure minimum depletion consistent with the safety of the dam.

iii) The inflow shall be calculated with reference to the increase or decrease in storage, issues, evaporation etc.

24.7 On the whole, the water regulation rules framed for operating the Vaniar Scheme are scientific and equitable. There may be deficiencies in one or two aspects. A review of the same is furnished below:

24.7.1 HYDROLOGICAL REVIEW

The reservoir was formed with a view to stabilise the existing old command of 796.03 hectares at a duty of 25 acres per M.Cft. of water. Based on the requirement of water at the above rates, gross capacity of the reservoir was kept at 418 M.Cft. (11.84 M.cum) with two fillings.

From the study of the statements showing the inflow and outflow of the reservoir from the years 1984-85 to 1994-95, it can be seen that except in the years 1991-92, 1993-94 and 1994-95, there has been shortfall in the inflows into reservoir. Seven out of ten years have been found to be deficit years.

23.7.2 Deficiency Concerning Venkatasamudram Anicut System

The assumption that Vaniar Reservoir is intended only to stabilise the existing old command is not totally justified.

Venkatasamudram anicut, which is the first anicut below Vaniar Reservoir feeds Venkatasamudram tank which commands an ayacut of 138.77 ha. (342.91 acres) besides catering to a direct command of 52.20 ha. (128.99 acres). This anicut is situated about one kilometer downstream of the reservoir.

As per the memoir of Vaniar Minor Basin, Venkatasamudram tank has a free catchment of only 1.036 sq.km. (0.40 sq.miles). The yield from such a small catchment will be very meagre. The capacity of this tank is 9.75 M.cft.

The catchment for Venkatasumdram anicut can be taken as that for Vaniar Reservoir due to its proximity with the reservoir. The catchment for Vaniar Reservoir is 101.76 sq.kms. (39.29 sq.miles). It can be construed that the entire supply to the anicut and tank has been cut off by the reservoir. That means, Venkatasamudram anicut and tank are entitled for supply at the usual duty for wet command at 6 acres/M.cft. But the scheme report and draft Rules for water Regulation stipulate 25 acres per M.cft. which is neither sufficient nor justifiable in this case of Venkatasamudram sub-system only. But in actual practice and experience, the case is different. As aforesaid, 50 cusecs are supplied from first of September till this tank and four (4) lower down ones are filled up. Being the fist in the system, the farmers of this tank (Venkatasamudram) manage to keep their tank always full and feed their ayacut too at the same time. They keep on drawing water through the tanks sluices when the tank is getting filled up. In fact it is a case of overdrawal to the detriment of the lower down interests during the start of the irrigation season till the monsoon sets in. However the above practice of Venkatasamudram ayacutdars can not be considered entirely irregular. They are entitled for supply at 6 acres per M.Cft. The rules of regulation has to be modified in respect of the Venkatasamudram Anicut system alone.

24.7.3 The next anicut in the river is Alapuram anicut with a combined catchment of 171 sq.km. (66 sq.miles). This catchment includes Meenar, (which is a tributary of Vanir) which has its own catchment of 52 sq.kms (20 sq.miles),

which joins Vaniar upstream of Alapuram Anicut. 50 sq.miles of the catchment lie in Sherveroyan Hills which is influenced by Yercaud rainfall stations, with a dependable yield of 24.25 M.cft. per sq. mile of catchment and the remaining 16 sq.miles lie in he plains which is influenced by Harur Rainfall station with a dependable yield of 9.77 M.cft. per sq.mile

The total yield realised at Alapuram Anicut from its catchment after meeting the requirement of vaniar reservoir is worked out below:

Yeild from the Hilly catchment (50 x 24.25)	=	1212,50 M.cft.
Yield from the plains (16 x 9.77)	=	156.32 M.cft.
Total	=	**1368.82 M.cft.**
Deducting Vaniar storage for two fillings (418 x 2)	=	(-) 836.00 M.cft.
Adding dead storage	=	(+) 12.38 M.cft.
Total	=	**545.20 M.cft.**

Besides, Alapuram Tank has its own catchment of 21.89 sq.kms (8.45 sq.miles)

Yield from this catchment (8.45 x 9.77)	=	82.56 M.cft.
Therefore Total yield available (545.20 + 82.56)	=	626.76 M.cft.

This Alapuram anicut system is designed to cater to the following needs:

a)	Alapuram supply channel	-	202.04 acres
b)	Alapuram Tank	-	542.40 acres
c)	Ondhiyampatti Tank	-	36.00 acres
d)	Thankaroikottai Tank	-	79.00 acres

Hence, Water required for direct and indirect command under the Anicut = $\frac{242.04+542.40+36+79}{6} = \frac{859.44}{6}$ = 143.24 M.cft.

This is less than the yield available from the catchment. Hence provision in the scheme estimate and draft Rules for Water Regulation at 25 acres/M.cft. is sufficient. In fact there is a surplus of 627.76 - 143.22 = 484.54 M.cft. here which runs down.

24.7.4 The third anicut in the river is Elumichai Perumal Koil Anicut which has a free catchment of 12.94 sq.kms (5 sq.miles) and a combined catchment if 183.81 sq.kms (71 sq.miles). It feeds Parayapatti tank with a command of 114.53 ha. (283 acres) besides feeding a direct command of 75.19 ha. (185.80 acres).

Parayapatti tank has its own catchment of 1.75 sq.km (0.62 sq.mile). The requirement of water for direct and indirect command under Parayapatti anicut is as follows:

For cultivation for one wet crop	=	$\frac{185.5+283}{6}$	=	78.10 M.cft.
Less yield from its free catchment =		(0.62+5)x9.77	=(-)	54.88 M.cft.
				23.22 M.cft.
Yield from its combined catchment	=	1/5x71x9.77	=	138.73 M.cft.
Hence there is surplus availability to a quantum of		138.73 - 23.22	=	115.51 M.cft.

There is already an excess quantity of 484.54 M.cft. flowing from its upper anicut.

Except the first anicut the old system is self-sufficient. There is a net surplus to meet the lower down interests as well in Harur area.

From the above, it can be seen that there is no shortfall of water which shows that the scheme estimate provision is quite adequate except the first anicut below for which water has to be allowed over and above the scheme Report provision of 25 acres per M.cft. In practice, this requirement is being complied with every year.

As far as the indirect command is concerned, duty adopted in the scheme Estimate, is adequate.

24.7.5 For the last anicut namely Kanakkan anicut, the catchment area is 173.76 sq.m (450 sq.kms). Tributaries like Peeniar, and Kallar join Vaniar river upstream of Kanakkan Anicut. As the requirement for its command of 166.96 acres at duty of 6 açres/M.cft. is 28 M.cft. yield available from the catchment and supplementation from Vaniar reservoir can meet the requirement. Hence the scheme estimate provision at 25 acres/M.cft. may be adequate. In fact, here also there is a good surplus over and above its demand.

Based on the above analysis, Vaniar reservoir system meets the requirement of old command as noted below:

Name of Anicut/ Name of Tank or	Command Area (in acres) per M.cft.	Water Requirement @6 Acres per M.cft.	Yield @25 Acres Catchment	Supplementation From Reservoir	from Vaniar	Remarks
1	2	3	4	5	6	7
1. Venkatasamudram Anicut						
a) Venkatasamudram supply channel	128.99	21.50	-	-	-	50 cusecs is given
b) Venkatasamudram Tank	342.91	57.15	-	3.81	9.75	continuously for filling up tanks.

2. Alapuram Anicut						Hence Col
a) Alapuram supply channel	202.04	-	8.08	545.20	-	6 is filled upon this
b) Alapuram Tank	542.40	-	21.69	82.56	36.24	basis. But
c) Ondhiyampatti Tank	36.00	-	1.44	8.40	3.15	actual average
d) Thenikaraikottai Tank	79.00	-	3.16	14.66	8.84	drawal and
3. Elumichaiperumal Koil Anicut						more on an average abstraction is much
a) Elumichai perumal Koil Supply channel	185.80	-	7.43	-	-	110.2 M.cft. was released to this
b) Parayapatti Tank	283.00	-	11.00	6.06	10.61	old system
4. Kanakkan Anicut	166.86	-	6.83	169.76	-	
Total	**1967.00**	**78.65**	**59.48**	**830.45**	**68.59**	

Inferences: i) It would appear that the first sub-system is deficient; but the fact is otherwise; Being the first it overdraws and the tank is kept always full. The ayacut is also continuously supplied.

ii) The requirement for one wet crop in this old command is 1967/6 = 328.00 M.cft.

Add losses 20% = 65.60 M.cft.
Total = 393.60 M.cft.

But the system gets from it catchment and supplementation 830.45+68.59 = 899.04 M.cft.

This is more than double. Hence even two wet crops can be cultivated.

iii) Deficiency in cultivation extents is attributable to the internal imbalance in water management practices.

24.8 OPERATIONAL ASPECTS

The entitlement of old command is 78.65 + 59.48 = 138.13 M.cft. Average release to this old command during the past 10 years is 3.12 Mm³ (110.2 M.cft.) The deficiency is compensated by the yield from the independent catchment as shown above.

It may be true that the old command also suffers due to illegal pumping all along the river course and supply channels.

Ayacutdars of direct command in the old system take water in some places through open cutting of the supply channel and where sluices exist, there is no controlling arrangement to regulate the flow. The supply channels are silted up and covered with vegetation which hinders the flow. The main sluice for Venkatasamudram supply channel has been damaged and the screw gearing shutter at the head of Ondhiyampatti supply channel has been tampered with.

Indirect command gets its supply from five tanks which are generally fair. Controlling arrangements in the sluices of tanks are generally not in good condition, resulting in wastage of water.

The supply channel feeding Ondhiyampatti Tank, runs in deep cut with the result the erosions from the sides find their way to the channel obstructing the flow.

Supply to old command is effected through right main canal of Vaniar Reservoir. At L.S. 40 m of right main canal, a canal with a discharging capacity of 1.47 cumec (52 cusecs) takes off on the left side which discharges into the river course. It has not been possible to effect rush supplies with greater quantity at the head to thwart overdrawals in the intermediate anicuts by this arrangement. This may have to be improved along with a fool proof arrangements against overdrawl at Venkatasamudram and Alapuram anicuts off-takes

24.8.2 The tail end reaches of left main canal do not receive sufficient water because of its longer length and lesser command compared to the right main canal. Small quantity of water has to travel for a longer distance. Pilferage and evaporation and seepage enroute result in dwindling of supplies to the middle and tail end reaches.

The bed width of right main canal at tail end at LS 12.70 km is kept at 1.50 m and thereafter only unlined field bothies take off from the tail cistern to feed 182 ha. (450 acres). For such a small tail end command, the bed width provided is too much. It is learnt that this has been done to accommodate future extension.

The head sluices of branch canals are provided with screw gearing shutters whereas the D.I. sluices in the main and branch canals are provided with paddle shutters which are not suitable for proper water regulation.

Lining in some reaches has been disturbed. It is reported that the aqueduct at sixth kilo meter of right main canal leaks profusely hampering agricultural activities in the adjoining fields.

24.9 MANAGEMENT ASPECTS

24.9.1 From the cultivation statistics it can be seen that the average development under new command is just 12.89% compared to the average quantum of water allowed at 8.87 m.cum. against the stipulated quantity of 17.29 m.cum. Similarly the average development for the old command is 59.37% against the average quantum of water allowed at 3.12 m.cum.

As far as new command is concerned, the entire command under right main canal and most of left main canal, except the tail end reach, is well developed. The usual crops grown are paddy, sugarcane, and tapioca. But the revenue records do not reflect the ground realities, crops raised utilising canal water have been shown to have been raised utilising well water. It is an undisputed fact that wells get recharged when water is left into the canals. The

benefits accrued through the reservoir are conveniently overlooked as a result of which the government lose their revenue. The irrigation status report of SIWRC on this reservoir also reflects this view.

When the project was formulated, it was envisaged that the new command would be of irrigated dry crops. But in practice, farmers go in for wet cultivation such as paddy and sugarcane which strains the hydrological and ground water potential of the region. This practice affected the rights of a section of the old command also. Farmers in the upper reaches utilise more than their legitimate share of water. Revenue records show that the ryots of new command raised their crops solely utilising well water. This is not entirely correct. The distortions of this nature need to be sorted out. The grouping of ayacut under each sluice of right main canal could not be easily identified.

24.9.2 INTER DEPARTMENTAL CO-ORDINATION

The interaction between the Water Resources Organisation and the Revenue Department have to be vastly improved. The Agriculture and the Agricultural engineering departments have a definite role to play in this regard. The Co-operation Department too can contribute their mite in this regard. The benefits of the system as a whole and the operational efficiency of the scheme are not reflected in the cultivation statistics of the Revenue Department.

24.9.3 MAINTENANCE

Maintenance of the system is wanting in many aspects. This is partly due to insufficient staff and partly due to the paucity of funds. It is essential that the maintenance of the system is diligently looked into. The present tendency is to concentrate on the operational aspect of the system neglecting the maintenance aspects. A judicious blending of these two aspects will enhance the efficiency of the system.

The inflows and outflows of the Vaniar Reservoir for ten years are given below:

VANIAR RESERVOIR PROJECT - ANNUAL INFLOW AND OUTFLOW

Year (June to May)	Opening Balance (M.m^3)	Inflow	Outflow through: Right Main Canal Zone I	Right Main Canal Zone II	Right Main Canal Old Command	Left Main Canal Zone I	Left Main Canal Zone II	Spillway	Total	Losses	Closing Balance
1984-85	1.600	2.970	1.093	0.577	0.473	0.440	0.241	-	2.824	0.293	1.453
1985-86	1.453	18.878	4.673	4.760	3.809	1.887	1.601	-	16.420	0.651	3.260
1986-87	3.260	11.157	1.660	1.580	4.670	1.774	1.893	-	11.547	0.960	1.910
1987-88	1.910	11.917	2.432	2.758	1.780	2.003	1.784	-	10.757	0.550	2.520
1988-89	2.520	13.120	2.815	2.699	2.845	2.067	1.918	1.075	13.419	1.611	0.610
1989-90	0.610	8.473	1.945	1.126	3.703	0.958	0.755	-	8.486	0.177	0.420
1990-91	0.420	4.660	0.485	-	1.775	0.906	-	-	3.166	0.600	1.320
1991-92	1.320	43.104	2.240	2.431	5.524	3.128	1.636	29.094	44.053	0.021	0.350

1992-93	0.350	16.524	2.146	3.219	2.382	1.709	3.374	3.186	16.108	0.008	0.850
1993-94	0.850	62.196	2.593	3.018	2.200	2.736	2.921	48.408	61.876	-	1.170
1994-95	1.170	31.135	2.565	3.634	2.558	3.979	3.239	15.247	31.222	0.525	0.558
1995-96	0.558	8.989	-	-	-	-	-	-	-	0.296	9.251
(Upto Nov.'95)											

Considering 10 years from 1985-86 to 1994-95,
average inflow is 221.964/10 = 22.2 Mm^3

Average quantity of water allowed for
new command = 88.707/10 = 8.87 M.cum.

Average quantity of water allowed
for old command = 31.245/10 = 3.12 Mm^3

As far as annual inflow into the reservoir is concerned, in seven out of ten years between 1985 and 1994, the annual inflow is less than crop water requirement for both old and new command, without, of course, taking into consideration rainfall contribution in the command.

24.9.4 LEGAL FRAME WORK

As there is an existing old command, Vaniar reservoir has to give supply to sustain it. Except this, there is no other obligation, which this project is bound to keep up.

Power generation and drinking water supply and industrial requirements have not been contemplated under this Project. Hence there is no legal framework for this project.

24.10 CURRENT LEVEL OF FARMERS' INVOLVEMENT

24.10.1 Farmers' involvement is essential for the successful implementation of any irrigation supply schedules designed to achieve optimum efficiency.

In Vaniar command, two Farmers' Association are functioning, one for the old command and the other for the new command. They approach the PWD and Revenue officials to get their grievances pertaining to irrigation and land levies redressed. The irrigation conferences which are usually held at Dharmapuri is being utilised by the farmers to highlight their grievances against the deficiencies and allied matters pertaining to the water regulation. Their involvement ends at that.

Presently, they are treated as passive recipients of irrigation and are not adequately consulted on the operation and maintenance issues. They do not have a say in the decision making in respect of water regulation.

Among the two recognised Farmers' Associations functioning in the Vaniar Command, the one for new command has been registered in No.36/90 and that for old command has been registered in o.74/91. They contact the

PWD and Revenue officials whenever they are faced with problems pertaining to irrigation and irrigation levies and get them redressed. They don't have any say in the water management and are only passive recipients.

The non-involvement of farmers in the water regulation renders them unaccountable. This leads to misuse or over use of water by cutting open irrigation channels and damaging the irrigation structures.

If they are made the masters of the irrigation system below certain level and the operation and maintenance responsibilities upto a limit are passed on to them they are quite likely to adopt fair irrigation practices to suit a well managed main system.

24.10.2 A phased programme to transfer the responsibility to farmers, is suggested. The Water Resources Organisation will retain its responsibility of maintaining the main distribution system.

For direct supplies from the channel system and indirect supply from the tanks, the responsibility for the operation and maintenance of the network below the sluice gate would be formally handed over to the committee of sluice level farmers. The sluice out let should have a fixed discharge capacity based on the design duty.

In the case of direct supplies, the responsibility for the operation and maintenance of minors would be transferred to an Irrigation Council. Channel upto the head of the minor distributary having a command upto 200 ha. will be transferred to the irrigation council which will be a Registered Body under the State Registration Act. All the off-takes from the distributary i.e. minors and outlets will be proportional distributors sized on their command area. The distributary will be operated at full supply level even during the low supply in the main canal and this may require installation of additional regulating structures; operation and maintenance of tanks would be transferred to the irrigation council responsible for tank command.

In this context the objectives of water resources consolidation project are understood to have tuned to build farmers confidence in the programme of the system through a reliable and equitable distribution of water and operational plan development inconsultation with the farmers.

Stage II of water resources consolidation project provides for an incentive for the farmers to accept greater responsibility for subsequent maintenance. Farmers are expected to get actually involved in the planning and implementation of Stage I and Stage II works.

24.11 PRESENT SUPPLY ARRANGEMENTS

24.11.1 Agriculture

The reservoir sustains new command of 3460 ha. and stabilises old command of 796.03 ha. But for this there is no other arrangement for supply to agricultural research farms seed farms etc.

24.11.2 Industry

One co-operative sugar factory is situated in the command near Marukkalampatti hamlet of Alapuram Village. This factory has come up after the completion of the Reservoir. There is no built-in arrangement to supply water for this factory directly from the reservoir. A well is dug in the land acquired for the project which was subsequently transferred to the co-operative Department. This is situated about 0.7 km away from dam line. Heavy capacity pumps are installed to send water through long pipelines to factory premises. A Glucose factory is coming up in Pippireddipatti limits which may approach for similar facility.

24.11.4 Hydro Electric System

There is no hydroelectric system requiring supply from this Reservoir. No possibility for generating hydro power exists.

24.11.5 Fisheries

Fish is reared in the reservoir itself. There is no separate arrangement for supply for rearing fish.

24.11.6 Railways

There is no supplies to the Railways.

24.12 FISHERY ACTIVITIES IN VANIAR RESERVOIR

The reservoir affords suitable facilities for the development of fishing. The Fishery Department is involved in the fishery activities in the reservoir.

Sowing of seeds is done from May to July when there is no drawal of water for irrigation. Major varieties of fish reared are, (1) Katla, (2) Rohu, (3) Mirgal and (4) Common crops. These are the stocked varieties. In the unstocked varieties, Thilepia, Uluvai, Small Catfish.

Annual target for seeds is 50,000 nos. fishing is being done from April to March and intensive finishing is done from November to March. Average daily catch is about 40 to 50 kg. which may go upto 100 kg during November and December.

Fishing is done by share fishermen 50% of the catch, irrespective of whether they are stocked or unstocked varieties, will be shared by the share fishermen. No other payment is made to the fishermen except 50% of the catch. The fishermen will have their own nets and coracles for fishing. They use only country crafts and nets for fishing. About three families are engaged in the fishing activities.

The seeds for the stocked varieties are brought from Krishnagiri Reservoir, Hogenekkal, Chinnar Dam and sometimes from Mettur Reservoir.

The catch will be transported on head lods to the Fisheries Department office at dam site and sold to the public at Government fixed rates. The following are the prevalent rates:

i)	Stocked Varieties	@ Rs. 30 per kg.
ii)	Unstock Varieties :	
	- Thilepia	@ Rs. 17 per kg.
	- Small fish	@ Rs. 10 per kg.

Staff Pattern for Fishiculture

The following are the staff of the fisheries Department who are engaged in the fishing activities at Vaniar Dam Site.

i)	Fishery Overseer Grade I	-	1
ii)	Fishing Guard	-	1
iii)	Part-time Sweeper	-	1

The annual establishment charges works out to Rs. 90,000/-

During 1995-96 (upto February 14, 1996) fishing done in Vaniar Reservoir is as follows:

(1)	Katla	247	(4)	Common Crops	7
(2)	Rohu	96	(5)	Silver Corps	53
(3)	Mirgal	475	(6)	Thilepia	5387

Total value of the above is about Rs. 51,000/-

The Revenue realised is less than the esfablishment charges because of the lesser, sale rates fixed by the Government with a view to provide protein rich fish to the people at lesser cost.

24.15 PROPOSED IMPROVEMENTS AND RECTIFICATION CONTEMPLATED UNDER WATER RESOURCES CONSOLIDATION PROJECT

The scheme suffers from insufficient inflow into the reservoir. There is short fall in seven out of ten years considered recently. Though this may not form part of improvements and rectifications contemplated under the present proposals, yet it is proposed that the new command under the scheme has to be modified suitably.

24.15.1 It is also to be noted that as per original scheme report, the entitlement for old command under the system has been fixed at 78.68 M.Cft. But the above requirement as worked out in para 23.7.5 is above 138.13 M.cft. Only

after meeting this requirement for old command, new command will be fed. It is therefore suggested that first zone in both LMC and RMC can be given supply from the reservoir as is being done hither to. As far as second zone in both LMC and RMC is concerned, supply has to be effected according to the availability of water. Alternatively a conjunctive water use plan for both the zones can also be contemplated.

24.15.2 At present, supply to old command is effected through a sluice in right main canal. The carrying capacity of this leading canal is 1.47 cumec. (52 cusec.) only. This is insufficient to push through larger discharge into the river course. Hence it is proposed that the D.I. sluice atL.S. 50 m of LMC which was intended to feed the park, is improved so that additional 1.47 cumec (52 cusecs) is allowed to the river through the surplus course. This has also been suggested in the SIWARC report on the reservoir.

24.15.3 IMPROVEMENTS FOR THE OLD COMMAND

Head sluice for Venkatasamudram supply channel has been damaged. It is to be repaired.

The anicut is generally in good condition except some patchwork repairs which will have to be attended to.

The supply channel to tank is proposed to be lined with 1:3:6 cast-in-situ lining and the bund strengthened.

Sluices in the supply channel are proposed to be constructed with screw gearing arrangements.

Tank weirs are all right. But the sluices in the tank need repairs which will be attended to. The sluices are controlled by plugs and rod arrangements which will be replaced by screw gearing arrangements.

The second anicut in the system namely, Alapuram anicut is in fairly good condition and the head sluice for supply channel is also fair. The supply channel is proposed to be lined with cast-in-situ C.C. 1:3:6 lining.

Sluices will have to be provided with the screw gearing arrangements.

As far as tank weirs and sluices are concerned, they are in fair condition.

Ondhiyampatti and Thenkaraikottai tanks receive their supply from Alapuram tank from the left flank weir of Alapuram tank. The screw gearing shutter arrangement at the head of the supply channel has been disturbed and is to be repaired.

The supply channel to Ondhiyampatti tank is proposed to be lined. It is filled with muck from the top and sides which will have to be removed before lining.

Ondhiyampatti Tank weir and sluice are in fair condition.

Supply channel to Thenkaraikottai tank is also to be lined and the screw gearing shutter arrangements for tank sluices are to be provided.

During Ryots meeting, the farmers of Ondhiyampatti and Thenkaraikoggai tanks requested that a separate supply channel be excavated from the tail end of Alapuram supply channel along the foreshore of Alapuram tank as surplussing of Alapuram tank is rarely allowed. This bypass channel is estimated to cost Rs.36.56 lakhs as per a recent estimate.

The next anicut viz., Elumichair Perumal Koil anicut needs minor repairs which will have to be carried out. The supply channel is proposed to be lined with CC 1:3:6 cast in-situ concrete

The sluices in the supply channel are to be provided with screw gearing shutter arrangements. The head sluice of the supply channel is slightly damaged which will have to be repaired.

Tank weirs and sluices are in fair condition. Tank sluices are proposed to be provided with screw gearing shutter arrangements

Kanakkan Anicut is in good condition except some spalling of concrete in the solid apron on the downstream side. There are signs of earth being removed from the river bed upstream. This practice has to be controlled. The channel feeding the tanks and direct ayacut is proposed to be fined and the sluices provided with screw gearing shutter arrangements under WRCP. The ayacut in this area has not been developed. A comprehensive irrigation development plan has to be developed after detailed surveys and investigation. This can precede the improvements contemplated under WRCP.

24.15.4 IMPROVEMENTS SUGGESTED FOR THE NEW COMMAND

As Vaniar Reservoir scheme is just one decade (10 years) old, there is not much repair work in the system. Wherever there are damages in the irrigation sluices cross masonry works and the lining they are to be repaired and restored then and there.

The D.I. sluices in the main and branch canals are to be provided with screw gearing shutters.

The aqueduct at L.s. 5730 m is profusely leaking. The defects should be carefully identified and should be rectified. Provision of in-situ lining of the upstream embankment portion of aqueduct with CC 1:3:6 concrete 15 cms thick for a short distance may have to be proposed.

The field bothies are to be lined with one stone thick R.R. masonry over a mat concrete base, upto 10 hectares limit. This will help conserve some water.

The new command ayacutdars, during the farmers' meeting requested that the irrigation season for the new command be commenced from December and can last upto March instead of the present rule of September to December supplies.

This is not possible for the following reasons. Two fillings of the reservoir can be realised only during the period from September to December. As the storage in the Reservoir is depleted for irrigation of the cast new command of 8550 acres, the absence of inflows beyond the north-east monsoon period will leave the reservoir dry by early February. A conjunctive water use plan only can lead the dry crops in the new command to successful harvest if the start of the irrigation season in delayed as demanded.

24.15.5 From the study of recordings in the reservoir water register, it is seen that spill over discharges are very high during all the surplus years. During the years 1991-92, 1993-94 and 1994-95 the surplus passed over the spillway worked out to 67.5%, 77.8% and 50% of the inflows respectively. Attempts should be made and the infrastructure kept trim to fill up the distant tanks and feed their ayacuts profusely during these times. This will help recharging the ground water aquefers in the area.

24.15.6 CONJUNCTIVE WATER USE PLAN (FOR THE NEW COMMAND)

Water requirement of the new command at 14 acres per M.cft. is 611 M.cft. It is 710 M.cft. if the duty adopted is 12 acres per M.cft. The average inflow into the reservoir less the releases to the old command is 22.2 minus 3.12 = 19.08 $M.M^3$ or 674 M.cft. But due to limited storage capacity and occurrence of large inflows during short intervals this much volume can not be retained. Irrigation demands for dry crops starts usually after December and no appreciable inflolws take place after this month. During surplussing times, it is possible to run the canals field channels and the river course as well as drains as much full as possible. This can recharge the ground water to a great extent. When the usable storage in December being limited to about 400 M.cft. or less, and the irrigation demand of new ayacut for the full season being fixed at 611 M.cft. of 710 M.cft. a definite short fall in supplies will be faced by the farmers. Under these circumstances, a conjunctive water use plan can save the crops. The necessity to work out a detailed conjuctive water use plan is therefore paramount for the new command under the Vaniar system.

CHAPTER 25
ENVIRONMENTAL ASPECTS

25.1 GENERAL AWARENESS AND APPRECIATION

The environmental aspects of any programme are receiving greater attention of the people and attracting the critical review of the Governmental and Non-Governmental organisations engaged in this field now a days. Particularly the Water Resources and Power Development projects and inland transportation systems are brought into focus by the environmentalists as these projects have their pimpacts on wild life fisheries and waterlogging with consequent long term positive and negative effects on the ecology of the river system. For a simple example, while the Buckingham Canal turned out to be an open sewerage system in the city of Madras, the Periyar project has become a famous sanctuary. The later enhances the usefulness of the natural set-up without affecting the environs aspects, the former is a nuisance for the citizens living around and going by the side of it.

All projects have their impact on the natural environment. The environmental quality of a storage and distribution system is ensured by proper appreciation of the issues involved. The results in the environment with and without the project are analysed critically. The primary and secondary effects in the eco-system of the basin are studied. Where there is a conflict on the issues involved - viz.. ecology versus development - a judgement based on the resulting balance in favour of overall public interests, present and future, is the approach. However, if the work affects the very basic needs of the local public who cannot be rehabilitated has to be stayed. Judging on these criteria, the Vaniar Reservoir project has very little impact on the environment and ecology of the sub-basin. On the other hand, the advantages following its commissioning are many.

25.2 RESETTLEMENTS

To begin with, the focus was to start as many works as possible in the poromboke lands. This approach created avenues for the displaced persons for earning income before parting with their lands physically. Therefore, the consequences of uprooting of the families whose lands were taken over for the implementation of the project did not reach unmanageable levels. The poor and marginal farmers were awarded piece work contracts and their livelihood for over 5 years during which the execution of various components of the reservoir lasted was not affected. In façt the works of semi-skilled and unskilled nature were given to these people on nomination basis in anticipation of Government orders approving these procedures, so that they were not kept idle unduly long. Temporary set backs were taken in their strides. Later on with some skills and confidence so secured they turned to other similar avocations elsewhere and were able to get steady incomes. Local labourers who were only seasonally engaged in agriculture before, had works almost uninterruptedly during the construction stage of head works and canals and then moved on to settle in some convenient pockets in the new command of 8550 acres on their

own. A handful of hill tribes who had habitated in some portion of the hillock in the alignment of the earth dam moved out to other places voluntarily after earning their livelihood through their usual avocations and services to those who resided in the head works campus during the construction period.

25.3 A new but welcome development is from the fisheries angle. Prior to the formation of the reservoir the fishing was confined to anicut sites and tank beds in the Vaniar sub-system. The fishing rights were auctioned at these places by the Government which did not go beyond that stage. The quantity of the catches and the sale prices of the same were left to the private bidders and their agents. The trade was going on in a limited scale. The varieties marketed were largely small types.

The formation of the reservoir afforded facilities for the development of fishing. The Fisheries Department of the State Government is involved in the fishing activities here. The reservoir has become the centre of trade. Various varieties of fish, large and small are raised. The Government fixes the sale prices of the different types. The turn over is much more now; some times upto 100 kg. a day and the period of availability is also longer than before. It is from April to March; but intensive finishing is done from November to March. Fishing is done on share basis 50% is given to fishermen. Selling prices are fixed with a view to make available this protein rich food to larger sections of the public at affordable rates.

25.4 AESTHETIC EFFECTS - LOSS OF NATURALISM

Acquisition of patta, poromboke and reserve forest lands to a total extent of 250 ha (617.96 acres) was involved in the formation of the Vaniar Reservoir. These lands are situated within a radius of 2 km from the foot of the hills. A major part of these lands got converted into water spread of a small lake behind an earthen embankment, the rear slopes of which were turfed all along. A colony with roads lined with trees and rows of semi-permanent quarters and other utility structures of the same nature came up in a quardrangle while a formed surplus course and canals were put up little away from the campus area. The expanse of lands below the earth dam did not undergo vast changes. The old forest road was shifted to a higher elevation. No structures or monuments were existing in the water spread area. No place or site of historic or archaeological or scenic importance got submerged. The dam alignment abuts the steeply sloping hill on the right side, merges with hillock midway and meets the hight ground on the left side gently. The valley is narrow immediately behind the reservoir pool area. The embankment is high for a short distance only. Its turfed rear slope matches with the greenary elsewhere. Seen from a distance or viewed from the top of bund, the scene is not much different from what it was before. In fact the small colony studded with trees, the horticultural garden layout surrounded by the hills and high ground do little to affect the sylvan surroundings. The project site was not a tourist spot before. Now it is steadily attracting people who go on picnic during week ends and holidays. The wild barrenness of the valley is maintained beyond the campus area. There is no complaint about loss of naturalness; nor the aesthetic values of the place minimised.

25.5 EFFECTS OF CHANGED LANDUSE

In the storage area proper, the land use changed from seasonal agriculture to fishiculture and to some extent to recreational use too. In the downstream because of insurance against flood flows, land use close to river margins has become a stable proposition. In some areas housing and building activities have developed. Because of lesser flushings in the river, the sediment (flood) plains remained unaltered.

These factors have encouraged seasonal cultivation in the flood plains of the river. Nurseries and small gardens are seen in some places in the river course. However, these developments are not taking place in a large scale due to the vigilant attitude of the local ryots. There is a perceptible increase of coconut thopes in the command area. The coconut plantations have developed as an inter-crop along with the cultivation of tapioca, cotton and ground nut leading to the economic prosperity of the land holders especially in the new command.

25.6 RESERVOIR STORAGE IMPACTS

Of late doubts have arisen that earth tremours are caused by impoundment of water in the storages. Some of the dam disasters are also attributed to such impoundment. It is necessary to clear away such apprehensions by scientific reasoning. This is also an environmental aspect. Specific studies of such situations have not been made in respect of Vaniar.

CHAPTER 26
MAXIMUM FLOOD CONSIDERATIONS : PMF/SPF VALUES

26.1 Based on the height of the dam, which is 32 meters above the river bed level, the reservoir can be classified as medium Dam. It's catchment and capacities are however too small to merit its inclusion in this category. Yet according to the guidelines on safety inspection of dams, this classification as medium dam is valid. Therefore, the probable maximum flood (PMF) or standard project flood (SPF) shall be the project design flood to which value, the spillway capacity provided should conform to PMF is the largest flood which would be generated under the worst combination of mateorological and climatic conditions over the basin. For PMF, the precipitation factor is maximised taking into account the dew point temperatures prevailed in the region of the most critical storm transposed and the basin under consideration whereas for computing SPF such maximisation is not done. This is an advanced technique which is elaborate. Data of rainfall for a number of years for a number of stations in and around the basin are required. The readings of automatic rain gauges installed in the areas of interest would be valuable.

26.2 In the case of Vaniar, flood forecasting on the above sophisticated modern method was not attempted as this technique for arriving at the values of PMF or SPF was not in vogue when the scheme was formulated. The design flood was fixed at 654.9 cumecs (23120 cusecs) adopting the conventional approach of employing Ryves formula and assuming a generous value for the constant in that equation as explained in an earlier chapter. The designers and decision matters were then confident that the resulting value for the maximum discharge would be the maximum probable flood at Vaniar Site and this would not be exceeded during the life of the dam. They had the necessary wisdom and experience to take an appropriate view after studying the nature of the catchment and rain fall intensities. Since the commissioning of the dam 11 (eleven) years ago, nothing has happened to give the impression that their presumption is or may go wrong.

However, as an academic interest the department itself can arrange to work out the PMF for Vaniar, selection of critical storm to generate maximum run off at Vaniar site may be carefully done as the location topography and nature of Vaniar Catchment are unique. In view of the limited area of the catchment the PMP (probable maximum precipitation value) as per the Atlas maintained for the region by OWC may be made use of for arriving at the design flood.

26.3 ACTUAL FLOODS ENCOUNTERED

The floods so far realised at V.R.P. are far too less than the estimated quantity. As per the water readings register maintained at the dam site, it is noted that floods of the order of 2700 cusecs were discharged over the spillway for a short duration on one occassion in 10/93. There is no mention of any

other outflows in excess of this quantity at any time so far. This is the maximum limit as far as the outflows are concerned. One might ask whether there was inflows into the reservoir exceeding this rate of discharge at any point of time in the past.. The following analysis attempts to provide an answer to this question.

The following observations are recorded in the water level register every day throughout the year.

i) Reservoir Water Levels

ii) Rainfall in mm

iii) Evaporation losses

iv) Issues through the two main canal sluices

v) Releases to the old ayacut

vi) Releases to the new command

vii) Discharge over the spillway

Seepages through the dam measured at the 5 (five) V-notch sites are entered in a separate register. No automatic water level recorder is installed. The reservoir water level is measured from the gauge plates fixed to the tower head wall of the main canal sluice. No gauging sites are maintained either upstream or downstream of the dam. The flow computations are made with reference to water level elevations, height of openings above the site or crest adopting gauge curves or discharge formulae.

The water levels and releases over the years were studied. Steep or sudden increase in reservoir levels were noticed to have taken place only on a few occasions. The particulars about such significant rise inwater levels in the reservoir are furnished below:

Dates	Water Levels (in m)	Capacity (M.cft.)	Rainfall (in mm)
14.11.92	462.80	170.94	38
15.11.92	464.30	206.90	13
16.11.92	465.70	244.04	4
17.11.92	466.50	267.67	
18.11.92	467.10		
19.11.92	467.50		
20.11.92	467.80	306.97	Outflows were
21.11.92	468.30	323.30	negligible
22.11.92	469.00	347.15	
23.11.92	469.60		
24.11.92	469.60		

25.11.92	470.30		
26.11.92 (8.00 a.m)	470.50		
26.11.92 (3.15 p.m)	470.60		
27.11.92	470.60		
28.11.92 (8.00 a.m)	470.50		
28.11.92 (3.00 p.m)	470.50		
29.11.92	470.60		
30.11.92	470.70		

During 1993, gradual rise during the winter months only was noticed.

During 1994, significant rises in reservoir levels were noticed on the following dates:

03.11.94	464.70		
04.11.94	465.40		
05.11.94	466.30	261.16	No significant outflow
06.11.94	469.50	364.18	or evaporation losses
07.11.94	470.50		
08.11.94	470.60		

During the years 1990-91 no significant sudden increase in reservoir levels were noticed.

It can be seen that on two previous occasions, there were sudden rise :

a) During 24 hours from 22.11.92 8.00 a.m. to 23.11.92 8.00 a.m. the reservoir level had gone up by 0.6 m resulting in the increase in storage of 367.00 - 347.15 = nearly 30 M.cft. Therise from 16.11.92 to 17.11.92 was greater at 0.8 m but the quantity flowed into the reservoir was 267.61 - 244.07 = 23.54 M.cft. only which is less than the increase on the other day.

The only other occasion in which significant rise in water level was noted was on 06.11.94.

According to the readings recorded in the register the water level rose from 466.3 m on 05.11.94 (8.00 am) to 469.5 m on 06.11.94 (8.00 am) corresponding capacities were 261.16 M.cft. and 364.18 M.cft.

Therefore, quantity flowed in 24 hours as per register is 364.18 - 261.16 = 103.02 M.cft.

Hence rate of inflow = 1030.02/0.0864 = 1192 cusecs

There would have been a possibility that this rise would have come about sooner, i.e. at a shorter interval than 24 hours. Say between 8.00 a.m.. and 8.00 a.m. the next day. Then the inflow would have been double the above value i.e. 2384 cusecs. OR like the previous and the following day, a rise of 1 m would have occurred in major part of 24 hours say 20 hours and the balance rise of 3.2m - 1 = 2.20 m would have come about in the last part i.e. in 4 hours before 8.00 a.m. on 06.11.94. In that case the inflow rate would have been as follows:

Capacity at level 467.3 m	-	285.59 M.cft.
Capacity at level 469.5 m	-	364.18 M.cft.
Inflow quantity in 4 hours	-	78.59 M.cft.
Rate of inflow	-	5448 cusecs

This is far less than the flood discharge capacity provided.

Since there was no automatic water level recorder, these surmises and conjectures could not be altogether brushed aside. It is now ascertained that the dam site staff has been instructed to record readings at shorter intervals, even on an hourly basis during critical periods. Installation of an automatic water level recorders will only be a good proposition to calculate the inflow flood rates on a dependable basis.

CHAPTER 27
MAINTENANCE ASPECTS AND STAFFING

27.1 STATUS OF IRRIGATION DEVELOPMENT

A notable feature of the reservoir operation in Vaniar is that the storage could be built up mostly during the north-east monsoon season only. Water was released for cultivation in the new command after 15th or 30th December in almost all the years since commissioning. It is ascertained that the farmers of the New Command required irrigation only after December every year. The problem of tail end shortages is met within both the old and new commands. Paddy and sugarcane are the predominant crops in the old ayacut areas served by anicuts supply channels and tanks together with supplementations from Vaniar Reservoir. These crops are also cultivated by many farmers in the upper reaches of the new command as well, much against the rules of regulations notified for the supplies of reservoir waters for irrigation. This leads to diminution of supplies to the middle and tail end reaches. The irrigation work inspectors who control the water releases in the main canals and branches and distributaries claim that they march along the banks of the canals etc. during the day times when the canals are run for irrigation and operate the sluice gates in turns according to the schedules of supplies and see that the water reaches the tail end; but during nights the sluices in the upper reaches are illegally opened. The water control structures are also tampered with by unruly elements in many places. The operation staff are helpless in this kind of situation. They say that even under these difficult conditions some crops or other are cultivated in about 80% of the ayacut and the Revenue statistics of cultivation are gross under estimation. It is pointed out that the attempts initiated by PWD Water Resources Organisation for joint inspection to determine the areas benefited by the reservoir waters do not meet with success. In their opinion a realistic picture about the irrigation efficiency affecting the entire command can emerge if an independent agency consisting of academic experts and field researches oriented towards agricultural economy in this basin undertake a survey and submit a report. The Government Revenue, PWD and Agricultural officials can extent necessary assistance to the team so constituted. This is a good suggestion worth being favorably considered and acted upon.

27.2 STATUS OF PARTICIPATORY MANAGEMENT

No clear idea about the farmers' participation in irrigation management activities related to this scheme has emerged till date. There are only two farmers association functioning for the whole of the V.R.P. ayacut. The interests of the members stop with demands for water releases, extension of supplies beyond the notified date, upgrade the local distribution network and introduce new supply points. Meaningful co-operation among them in the matter of equitable distribution of water is totally absent. No uniform or fixed pattern of cultivation is followed. A strong entity to maintain disciplines among the beneficiaries is still to evolve. Its nature and composition may get resolved in the course of time. Opinions among the officials at the operational level be vested with the operation and maintenance staff of the project. This includes powers

to arrest and furnish the erring elements who interferes with the orderly irrigation and damage the control structures. Some feel that responsibility to collect levies and land taxes can be given to them. These are all very important policy issues to be decided at the highest level. It is not made clear whether this work can be handled by the existing personnel or additional staff will be drafted for the purpose.

27.3 COST OF UP-KEEP - RESPONSIBILITIES

The annual maintenance budget as per details furnished by the local officials in the WRCP report is Rs.22,51,000/-. This works out to Rs.530/- per ha. The amount provided for the salaries and wages of the operating personnel is Rs.8,57,000/- which is 38% of the expenditure proposed for the up-keep of the project infrastructure. As the allocation for the maintenance forms only 1.85% of the project cost of Rs.12 crores it cannot be considered excessive. In fact it may be more if performance efficiency of the scheme has to be increased. Under these circumstances it is to be pondered whether the total land revenue now being collected and any revision of it if contemplated would meet the cost of up-keep. Finding the ways and means of balancing the maintenance budget or reducing its deficit it is the need of the hour. Farmers' involvement in the management activities may provide a helping hand in this regard.

The benefits of research and consequent green revolution were/and or being/largely cornered by crops like, wheat, sugarcane and cotton and to a lesser extent rice. In the matter of irrigation too, these crops receive preferential treatments. Balanced cultivations which should include such crops as pulses, oil seeds and coarse grains are necessary to meet the nutritional needs of the public. Water management is a key problem in encouraging balanced cultivations in scheme ayacuts. But this is not merely an engineering problem; it is eminently a social problem too, as it concerns with land consolidation, loans and other inputs. Hence any organisation or arrangement for water management should first receive the approval or recognition of the farming community. A concensus has to be arrived at about its composition and the powers it can excise. The Government officials in the WRCP, Agriculture, Revenue and Co-operation Departments may interact with the agriculturists of the area to constitute anentity or entities which will manage the water distribution below the storage level. Technical guidance may continue to be extended by the Water Resources Organisation. Imparting of skills to such bodies to carry out the tasks and responsibilities satisfactorily is the second stage in the process. The various training institutes operating in the state can provide assistance in this regard. This sort of turn over programmes has to cover this Vaniar command sooner or later so that the dependence on Government resources is minimised.

27.4 CURRENT OPERATION AND MAINTENANCE MANAGEMENT

One Section Officer is in charge of Vaniar Reservoir with head quarters at Harur. The section, presently headed by a Junior Engineer, looks after the operation and maintenance of Reservoir and Distribution system for the new command.

Another section, with head quarters at Pappireddipatti, headed by an Assistant Engineer at present, looks after the old command under Vaniar Reservoir and other Tanks and building maintenance works.

These sections are attached to sub-division at Harur, which in turn comes under the control of the Executive Engineer PWD, Water Resources Organisation, Upper Ponniyar Division, Dharmapuri.

Vaniar Section is manned by the following personnel:

Junior Engineer	1 No.
Office Assistant	1 No.
Work Inspector	3 Nos.
Irrigation Assistant	1 No.
Mazdoor	1 No.
Watchman	1 No.
Technical Assistant (NMR)	
Mazdoors (seasonal)	3 Nos. (they have since been brought to regular establishment).

Pappireddipatti section is manned by the following personnel:

Break-up Details of Personnel over previous five years:

Category	1991	1992	1993	1994	1995
Regular Staff	4	4	4	4	4
Work Charged Establishment					
- Harur Section	20	20	20	20	20
- Pappireddipatti Section	4	4	4	4	4

ORGANISATION CHART

ENGINEER-IN-CHIEF
Water Resources Organisation (WRO)
Madras

↓

CHIEF ENGINEER, PWD
Madras Region (WRO)
Madras

↓

SUPERINTENDING ENGINEER PWD (WRO)
Pennaiyar Basin Circle
Krishnagiri

↓

EXECUTIVE ENGINEER, PWD (WRO)
Upper Pennaiyar Basin Division
Dharmpauri

↓

ASSISTANT EXECUTIVE ENGINEER, PWD (WRO)
Harur Sub-Division
Harur

VANIAR SECTION, HARUR

- Work Inspection - 3 Nos.
- Irrigation Assistant - 1 No.
- Mazdoor - 1 No.
- Watchman - 1 No.
- Technical Assistant (NMR) - 1 No.
- Mazdoors - 13 Nos. (since regularised)

PAPPIREDDIPATTI SECTION

- Work Inspectors - 3 Nos.
- Fitter - 3 Nos.
- Mazdoors (to be assigned from Vaniar section during Flood season)

The sub-divisional Officer, Harur has jurisdiction over whole of Harur and parts of Uthankarai Taluks. The two section Officers too have works and responsibilities in respect of conservation of water resources in Harur Taluk besides Vaniar Scheme

27.6 CURRENT OPERATION AND MAINTENANCE BUDGET

Current O & M budget in terms of staff, contract materials, fuel and communication is given below:

Sl. No.	Description	Amount	Remarks
1.	Regular Staff	1,35,000	
2.	Work charged staff	5,87,000	
3.	Works contract	12,00,000	Maintenance of canals, anicuts, etc.
4.	Maintenance of Dam canal etc.	2,00,000	
5.	Fuel	42,000	
6.	NMR Wages	93,000	

Cost of maintenance 22,57,000/4256 = Rs. 530 per ha.

27.7 PREVIOUS OPERATION AND MAINTENANCE

Sl. No.	Description	Annual O & M Budget. Bid (Rs.)	Actual O & M Expenditure (Rs.)
1.	Regular Staff	1,10,000	1,10,000
2.	Work charged Estt.	2,25,000	2,25,000
3.	Repairs	7,50,000	7,50,000
4.	Wages	2,50,000	2,50,000
5.	Miscellaneous charges	1,50,000	1,50,000
		14,85,000	**14,85,000**

27.8 ESTIMATED ANNUAL OPERATION AND MAINTENANCE BUDGET REQUIRED AFTER STAGE I REHABILITATION WORKS HAVE BEEN COMPLETED

(only for works connected with canals and Anicuts)

a) **Regular Staff**

i) Work Inspectors @ 2 Nos. for Pappireddipatti and 3 Nos. for Harur sections. } 5 Nos.

ii) Irrigation Assistants @ 1 No. for 500 ha. of command. } 12 Nos.
- Old Command : 5 Nos.
- New Command : 7 Nos.

b) **Work Charged Staff**

- Nil -

c) Contracted Service (for maintaining Canals and Anicuts)

d) Materials and Fuels:

COST ABSTRACTS:

Number	Details	Rate	Per x 12	Amount (Rs.)
	a) Regular Staff			
5 nos.	Work Inspectors	3,500		2,10,000
12 nos.	Irrigation Assistant	2,500		3,60,000
Nil	b) Work charged staff	Nil		
LS	c) Contracted service	-		5,00,000
LS	d) Materials and Fuel	-		30,000
				10,00,000

27.9 LIST OF EQUIPMENT CONSIDERED NECESSARY FOR EFFICIENT O & M

1. Vehicles - One Jeep for the Sub-Division
2. Plant - One Lorry or light vehicle
3. Tools & Equipment - Spades, crow bars, baskets, turnkeys, spanner sets, torch lights, petromax, iron hand hammers for compactions, lamps, floodstock as per G.O. etc.
4. Workshop Equipment - May be arranged on Hire
5. Survey Equipment - 2 nos. quick setting levelling instrument with staff.
6. Measuring Equipment - Steel tapes, ranging rods, compass, survey equipment.
7. Office Equipment - Furniture, typewriter.

27.10 COMMUNICATIONS, ETC.

A telephone connection in the office of the Assistant Executive Engineer, Harur is necessary. The two Section Officers and a few Work Inspectors are to be encouraged to own and maintain motor bikes. Subsidies and loans may be extended to them for this purpose. During the winter months of October, November and December arrangements are usually made to have one responsible person on duty in sub-division office, one in the Section Office and one in the dam site almost round the clock. The Mazdoors and Work Inspectors are to take up the positions in turns in each of the above offices. Instructions are already issued to the Assistant Executive Engineer to conduct a flood drill at the dam site once every year prior to the on set of the monsoon so that the operating personnel feel confident to manage the system when large inflows are encountered. The staff are aware that storage and safety aspects are to be taken care of judiciously as stipulated in the rules of regulation.

Vaniar is a small compact irrigation potential created about a decade ago. It has come up in a backward interior area. Quite many steps are taken and measures adopted to utilise this asset efficiently. By and large the present staff appears to be familiar with these procedures. There may still be room to improve its performance. It is desirable that the Assistant Executive Engineer and Assistant Engineer record briefly their experience every year and send them along with the prescribed annual statements on the status of Dam components and canals system.

ANNEXURE

VANIAR RESERVOIR SYSTEM
LAND USE PATTERN

Sl. No.	Description	Pappireddipatti Block			Harur Block		
		Irri gated	Unirri gated	Total	Irri gated	Unirri gatted	Total
1.	Paddy	ha	ha	ha	ha	ha	ha
	a) Kharft	131	-	131	133	-	133
	b) Rabi	5527	-	5527	-	-	-
2.	Cholam	-	1439	1439	-	6963	6963
3.	Ragi	1499	1075	2574	1605	454	2063
4.	Pulses	21	2187	2208	-	-	-
5.	Oil seeds	2878	2283	5161	3668	3515	7183
6.	Cotton	585	1128	1713	-	-	-
7.	Other crops	4368	902	5270	247	14112	14359
8.	Red gram	-	-	-	-	11872	1872
9.	Block gram	-	-	-	43	666	709
10.	Green gram	-	-	-	38	400	438
11.	Cumbu	-	-	-	372	275	647
	Total	**15009**	**9014**	**24023**	**9710**	**28257**	**37967**

ANNEXURE

VANIAR RESERVOIR PROJECT, PWD DIVISION, HARUR.

SPECIAL PROJECT CIRCLE KRISHNAGIRI.

DETAILS OF CROSS MASONRIES IN RIGHT MAIN CANAL V.R.P.

Sl.No.	L.S. in Meters	Details of cross masonry
1.	60	Road culvert cum 1 M drop
2.	120	1.75 M drop
3.	150	Under Tunnel
4.	200	Regulator with D.I. sluice
5.	350	D.I. sluice
6.	360	1 M drop
7.	556	0.98 M drop
8.	630	Canal syphon
9.	800	D.I. sluice
10.	850	Foot bridge
11.	1125	Road culvert
12.	1295	Super passage
13.	1365	Super passage
14.	1575	Super passage
15.	1625	Super passage
16.	1725	S.I. sluice
17.	1775	Super passage
18.	1900	Super passage
19.	2125	Under Tunnel
20.	2135	Road culvrt
21.	2225	Super passage
22.	2400	Drop
23.	2425	Super passage
24.	2325	Under Tunnel
25.	2450	D.I. sluice
26.	2610	Under Tunnel
27.	2800	Food bridge
28.	3090	Off take sluice

29.	3100	Drop cum road culvert
30.	3200	D.I. sluice
31.	3500	2 M drop
32.	3700	2 M drop
33.	3800	1.5 M drop
34.	3815	Road culvert
35.	3875	D.I. sluice
36.	3900	1 M drop
37.	4225	Head sluice for Branch Canal
38.	4350	1.7 M drop cum culvert
39.	4350	D.I. sluice
40.	4375	2 M drop
41.	4550	1.70 M drop
42.	4575	Super passage
43.	4700	D.I. sluice
44.	4865	2.07 M drop
45.	4915	1.10 M drop
46.	5250	D.I. sluice
47.	5500	Super passage
48.	5750	D.I. sluice
49.	5760	Super passage
50.	5925	Super passage
51.	6100	D.I. sluice
52.	6225	Super passage
53.	6405	Super passage
54.	6510	Under Tunnel
55.	6710	Super passage
56.	6900	D.I. sluice
57.	6960	Super passage
58.	7020	Super passage
59.	7270	Super passage
60.	7350	D.I. Sluice
61.	7630	Super passage
62.	7750	D.I. sluice
63.	7795	Super passage

64.	7795	Under Tunnel
65.	8200	Super passage
66.	8300	D.I. sluice
67.	8322	Super passage
68.	8400	Super passage
69.	8500	Super passage
70.	8538	Super passage
71.	896	Super passage
72.	9100	D.I. sluice
73.	9140	Super passage
74.	9371	Super passage
75.	9475	D.I. sluice
76.	9660	D.I. sluice
77.	9775	D.I. sluice
78.	9795	Road culvert
79.	9875	D.I. sluice
80.	9900	1 M drop
81.	10050	1 M drop
82.	10150	D.I. sluice
83.	10210	1 M drop
84.	10250	D.I. sluice
85.	10305	1 M drop
86.	10405	1 M drop
87.	10480	1 M drop
88.	10560	1 M drop
89.	10625	Road culvert
90.	10640	D.I. sluice
91.	10685	1 M drop
92.	10820	D.I. sluice
93.	10850	1 M drop
94.	10985	1 M drop
95.	11050	1 M drop
96.	11162	Road bridge
97.	11190	D.I. sluice
98.	11200	1 M drop

99.	11295	1 M drop
100.	11375	1 M drop
101.	11410	D.I. sluice
102.	11475	1 M drop
103.	11610	D.I. sluice
104.	11735	Road culvert
105.	11750	D.I. sluice
106.	11805	1 M drop
107.	11850	D.I. sluice
108.	11910	1 M drop
109.	11980	D.I. sluice
110.	12030	1 M drop
111.	12130	1 M drop
112.	12200	1 M drop
113.	12320	1 M drop
114.	12450	Tail dam.

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur.

VANIAR RESERVOIR PROJECT, P.W.D.
DIVISION, HARUR.

SPECIAL PROJECT CIRCLE
KRISHNAGIRI.

DETAILS OF CROSS MASONRIES IN BRANCH CANAL I OF RIGHT MAIN CANAL.

Sl.No.	L.S. in Meters	Details of cross masonry
1.	33	Super passage
2.	148	Road culvert
3.	260	Well drop
4.	385	D.I. sluice
5.	525	Well drop
6.	585	Under Tunnel
7.	710	D.I. sluice
8.	895	Super passage
9.	925	Road culvert
10.	940	D.I. sluice
11.	1025	Super passage
12.	1185	Super passage
13.	1610	Road culvert
14.	1625	D.I. sluice
15.	1770	D.I. sluice
16.	1870	D.I. sluice
17.	1925	Dividing dam
18.	1972	D.I. sluice
19.	2865	Tail dam.

Sd/-
Executive Engineer, PWD,
V.R.P. Division, Harur.

VANIAR RESERVOIR PROJECT, P.W.D. DIVISION, HARUR.

SPECIAL PROJECT CIRCLE KRISHNAGIRI.

DETAILS OF CROSS MASONARY WORKS IN BRANCH CANAL, I.A. OF RIGHT MAIN CANAL.

Sl.No.	L.S. in Meters	Details of cross masonry
1.	75	Well drop
2.	150	Well drop
3.	400	Well drop
4.	450	Road culvert
5.	494	D.I. sluice
6.	525	Well drop
7.	609	D.I. sluice
8.	675	Well drop
9.	750	Well drop
10.	810	D.I. sluice
11.	815	Well drop
12.	895	D.I. sluice
13.	900	Well drop
14.	1150	Well drop
15.	1244	D.I. sluice
16.	1250	Well drop
17.	1335	Road culvert
18.	1344	D.I. sluice
19.	1400	Well drop
20.	1507	Well drop
21.	1685	D.I. sluice
22.	1690	Super passage
23.	1700	Well drop
24.	1836	D.I. sluice
25.	1850	Foot Bridge
26.	1985	Well drop
27.	2050	Well drop
28.	2104	Pipe culvert
29.	2125	Tail dam

DETAILS OF CROSS MASONRY WORKS IN BRANCH CANAL II OF RIGHT MAIN CANAL IN V.R.P.

Sl.No.	L.S. in Meters	Details of works
1.	161	Road culvert
2.	180	D.I. sluice
3.	200	D.I. sluice
4.	225	Well drop
5.	375	Well drop
6.	462	Road culvert
7.	782	Super passage
8.	1136	Road culvert
9.	1160	D.I. sluice
10.	1775	Road culvert
11.	1900	Super passage
12.	1950	D.I. sluice
13.	2200	D.I. sluice
14.	2400	D.I. sluice
15.	2775	Super passage
16.	2860	Well drop
17.	2900	D.I. sluice
18.	2925	Super passage
19.	2995	Super passage
20.	3150	D.I. sluice
21.	3300	D.I. sluice
22.	3520	Well drop
23.	3585	Well drop
24.	3610	Super passage
25.	3955	Super passage
26.	4080	D.I. sluice

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur.

DETAILS OF CROSS MASONRIES II LEFT MAIN CANAL AND ITS BRANCHES OF VANIAR RESERVOIR PROJECT

Sl.No.	L.S. in Meters	Details of cross masonry
1.	0	Head sluice
2.	59(R)	D.I. sluice
3.	150	Aqueduct
4.	385(R)	D.I. sluice
5.	533(R)	D.I. sluice
6.	590	Under Tunnel
7.	875	Super passage
8.	987	Head sluice for Branch Canal I
9.	1226	Road culvert
10.	1648	Pipe culvert
11.	1846	Super passage
12.	2193	Road culvert
13.	2129(R)	D.I. sluice
14.	2231	Road culvert
15.	2450	Foot Bridge
16.	2694(R)	Head sluice for Distributory
17.	2798	Foot Bridges
18.	3266	Foot Bridges
19.	3418	Foot Bridges
20.	3510	Road culvert
21.	3577	Under Tonnel
22.	3720	Foot Bridges
23.	3725(R)	D.I. sluice
24.	3897	Under Tonnel
25.	3990	Foot Bridges
26.	4134(R)	D.I. sluice
27.	4145	Foot Bridges
28.	4397	Foot Bridges
29.	4485	Super passage
30.	4541(R)	D.I. sluice
31.	4765	Road culvert
32.	4868	Foot Bridges
33.	5083	Road culvert

34.	5192(R)	D.I. sluice
35.	5213	Foot Bridges
36.	5351	Syphon
37.	5407	Foot Bridge
38.	5550(R)	D.I. sluice
39.	5706	Trough Aqueduct
40.	5773	Foot Bridge
41.	5910	Super passage
42.	6000	D.I. sluice
43.	6193	Super passage
44.	6423	- do -
45.	6567	Foot Bridge
46.	6578	D.I. sluice
47.	6771(R)	Head sluce branch canal III
48.	6837	Foot Bridge
49.	6925	Aqueduct
50.	6979	Road culvert
51.	7065	Foot Bridge
52.	7138	Super passage
53.	7300(R)	D.I. sluice
54.	7365 M	Foot Bridge
55.	7455	Super passage
56.	7558	Foot Bridge
57.	7605	Under Tonnel
58.	7640(R)	D.I. sluice
59.	7655	Under Tunnel
60.	7663	Culvert
61.	7907	D.I. sluice
62.		Pipe crossing
63.	8306	Super passage
64.	8135	D.I. sluice
65.	8294	Road culvert
66.	8338	Head sluice of Distributory
67.	8523	Road culvert cum super passage
68.	8665	Super passage
69.	8807	Pipe culvert
70.	8892	Foot Bridge

71.	8930	Trough Aqueduct
72.	9062	Super passage cum Road Culvert
73.	9238	Foot Bridges
74.	9253	Under Tunnel
75.	9263	Foot Bridges
76.	9401	Foot Bridges
77.	9478	D.I. sluice
78.	9518	Well drop 1.00 M
79.	9646	Foot Bridge
80.	9719	Foot Bridge
81.	9788	D.I. sluice
82.	9802	Foot Bridge
83.	9886	Foot Bridge
84.	9945	Under Tunnel
85.	9972	Foot Bridge
86.	10035	Road culvert
87.	10071	D.I. sluice
88.	10173	Foot Bridge
89.	10231(R)	Head sluice for Branch Canal II
90.	10250	Regulator
91.	10297	Super passage
92.	10357	D.I. sluice
93.	10550	Super passage
94.	10675	Foot Bridges
95.	10740	Canal syphon
96.	10780	Foot Bridges
97.	10809	Well drop
98.	10881	Supern passage
99.	11040	D.I. sluice
100.	11066	Well drop cum Super passage
101.	11164	Well drop
102.	11330	Super passage
103.	11402	D.I. sluice
104.	11420	Super passage
105.	11653	Super passage
106.	11833	Super passage
107.	11874	D.I. sluice

108.	12090	Super passage
109.	12287	Under Tunnel
110.	12309	Foot Bridges
111.	12394	D.I. sluice
112.	12508	D.I. sluice
113.	12581	Road culvert
114.	12597	Head sluice for **Branch Canal V**
115.	12723	Well drop
116.	12824	Aqueduct
117.	12936	Foot Bridges
118.	13013	Foot Bridges
119.	13139	Super Bridges
120.	13254	Foot Bridge
121.	13287	D.I. sluice
122.	13493	D.I. sluice
123.	13535	Foot Bridges
124.	13617	Foot Bridges
125.	13715	Pipe crossing
126.	13747	Road culvert
127.	13818	D.I. sluice
128.	13969	Super passage
129.	14068	Super passage
130.	14157	Super passage
131.	14189	D.I. sluice
132.	14292	Super passage
133.	14304	D.I. sluice
134.	14450	D.I. sluice
135.	14456	Foot bridge
136.	14662	Super passage
137.	14769	Road culvert
138.	14948	D.I. sluice
139.	15194	Foot bridge
140.	15329	Trough Aqueduct
141.	15650	D.I. sluice
142.	15729	Foot Bridge
143.	15775	D.I. sluice
144.	15787	Well Drop

145.	15877	Road culvert
146.	16308	Super passage
147.	16722	Trough Aqueduct
148.	16827	Road culvert
149.	17189	Road culvert
150.	17576	Road culvert
151.	17797	Road culvert
152.	17931	Well drop
153.	17933	Foot Bridge
154.	17980	Road culvert
155.	18195	Road culvert
156.	18398	- do -
157.	18512	- do -
158.	18659	Foot Bridge
159.	18837	Road culvert

Sd/- Executive Engineer, PWD.
V.R.P. Division, Harur.

BRANCH I OF LEFT MAIN CANAL OFF TAKING AT L.S. 987M.

Sl.No.	L.S.	Name of work
1.	0	Head sluice
2.	141	D.I. sluice
3.	209	Super passage
4.	523(R)	D.I. sluice
5.	595	Super passage
6.	603	D.I. sluice
7.	815	D.I. sluice
8.	915	Super passage
9.	1020	D,I. sluice
10.	1088	Tail dam

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur.

VANIAR RESERVOIR PROJECT, P.W.D.
DIVISION, HARUR.

SPECIAL PROJECT CIRCLE
KRISHNAGIRI.

DISTRIBUTORY OFF TAKING AT L.S. 2964 OF LEFT MAIN CANAL.

Sl.No.	L.S.	Name of work
1.	0	Head sluice
2.	85 (L)	D.I. sluice
3.	85 (R)	D.I. sluice
4.	113	Well drop
5.	193	D.I. sluice
6.	209	Well drop
7.	303	D.I. sluice
8.	310	Well drop
9.	412	Well drop
10.	420	Pipe culvert
11.	457	D.I. sluice
12.	536	Pipe culvert
13.	591	Well drop
14.	624	Pipe culvert
15.	665	D.I. sluice
16.	673	Well drop
17.	726	Pipe culvert
18.	768	Well drop
19.	897	Pipe culvert
20.	902	Well drop
21.	979	Well drop
22.	1073	Pipe culvert
23.	1100	Tail dam

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur.

VANIAR RESERVOIR PROJECT, P.W.D. DIVISION, HARUR.

SPECIAL PROJECT CIRCLE KRISHNAGIRI.

BRANCH CANAL III AT L.S. 6771 M OF LEFT MAIN CANAL

Sl.No.	L.S.	Name of work
1.	0	Head sluice
2.	119(L)	D.I. sluice
3.	456	Foot Bridge
4.	518	D.I. sluice
5.	623	Foot Bridge
6.	777	Pipe crossing
7.	795	D.I. sluice
8.	893	Foot Bridge
9.	1040	Road culvert
10.	1196(L)	D.I. sluice (4)
11.	1196(R)	D.I. sluice (5)
12.	1219	Foot Bridge
13.	1349	Foot Bridge
14.	1432	Pipe culvert
15.	1560	Super passage
16.	1638	Drain crossing
17.	1663	D.I. sluice
18.	1777	Foot Bridge
19.	1816	Tail dam

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur

VANIAR RESERVOIR PROJECT, P.W.D.
DIVISION, HARUR.

SPECIAL PROJECT CIRCLE
KRISHNAGIRI.

DISTRIBUTORY OF TAKING OFF AT L.S. 8338 M OF LEFT MAIN CANAL

Sl.No.	L.S.	Name of work
1.	30(L)	D.I. sluice
2.	30(R)	D.I. sluice
3.	46	Well drop 1 M
4.	64	Foot bridge
5.	148	D.I. sluice
6.	158	Well drop
7.	247	Well drop
8.	321	Well drop
9.	361	Foot bridge
10.	398	Super passage
11.	398	Pipe aqueduct
12.	401	Well drop
13.	437	Foot Bridge
14.	486	D.I. sluice
15.		Well drop
16.	543	Pipe culvert
17.	632(L)	D.I. sluice
18.	632(R)	D.I. sluice
19.	637	Pipe culvert
20.	676	Tail dam

Sd/-
Executive Engineer, PWD
V.R.P. Division, Harur.

VANIAR RESERVOIR PROJECT, P.W.D. DIVISION, HARUR.

SPECIAL PROJECT CIRCLE KRISHNAGIRI.

BRANCH CANAL IV OF LEFT MAIN CANAL AT L.S. 10231 M

Sl.No.	L.S.	Name of work
1.	0	Head sluice
2.	290	Pipe culvert
3.	464	Road culvert
4.	571	Road culvert
5.	607	Foot Bridge
6.	614	D.I. sluice
7.	682	Pipe crossing
8.	738	Foot Bridge
9.	859	Super passage
10.	915	D.I. sluice
11.	1129	Pipe culvert
12.	1191	D.I. sluice
13.	1209	Super passage
14.	1362	Syphon
15.	1526	Super passage
16.	1644	D.I. sluice
17.	1653	Super passage
18.	1713	Tail Dam

Sd/- Executive Engineer, PW
V.R.P. Division, Harur.

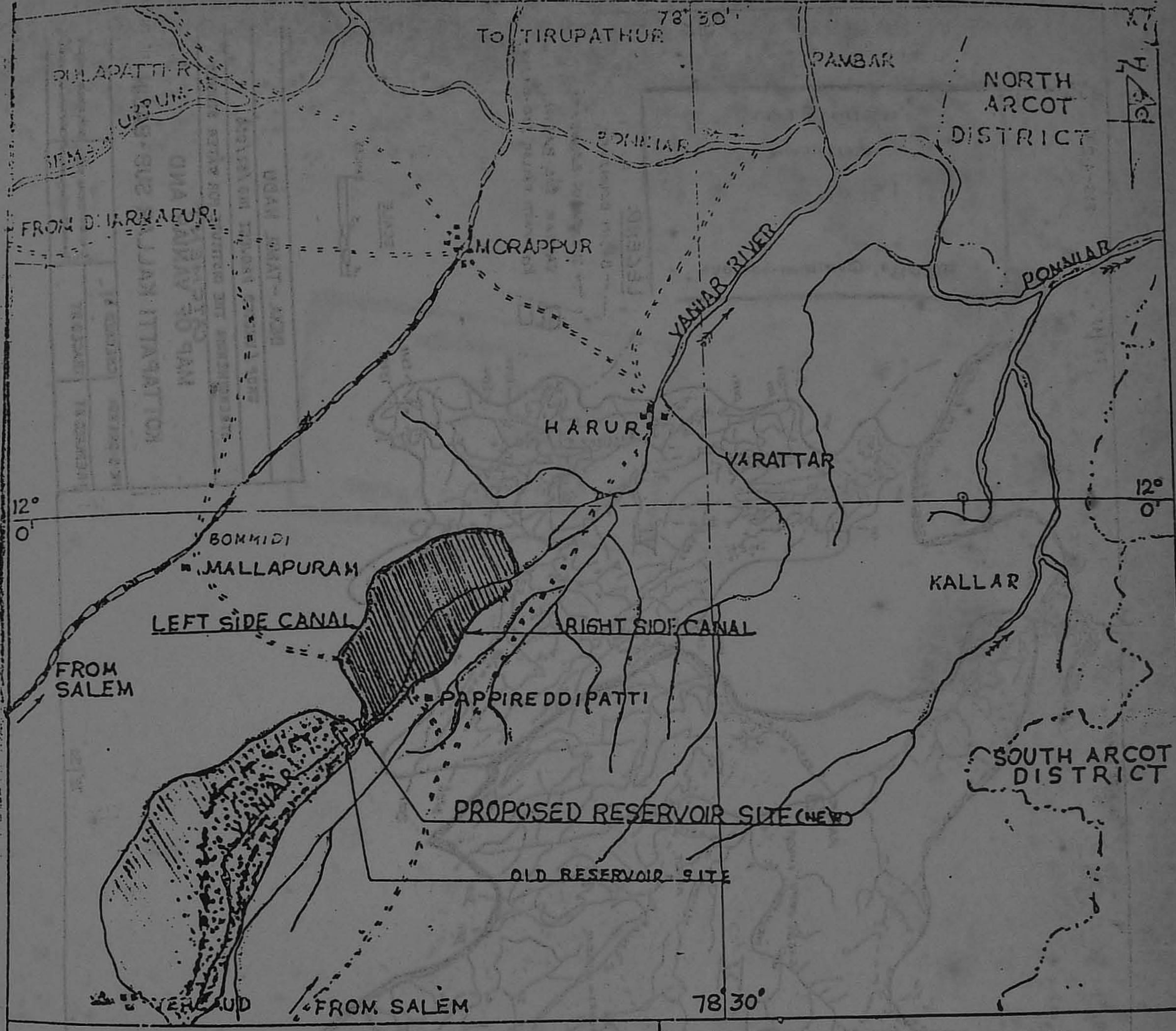
VANIAR RESERVOIR PROJECT, P.W.D. DIVISION, HARUR.

SPECIAL PROJECT CIRCLE KRISHNAGIRI.

BRANCH CANAL V OF LEFT MAIN CANAL AT L.S. 12597 M.

Sl.No.	L.S.	Name of work
1.	0	Head sluice
2.	98	Pipe culvert
3.	339	D.I. sluice
4.	350	Well drop
5.	391	Foot Bridge
6.	598	Pipe culvert
7.	606	D.I. sluice
8.	713	Foot Bridge
9.	718	D.I. sluice
10.	727	Well drop
11.	832	D.I. sluice
12.	974	Foot Bridge
13.	1081	Pipe crossing
14.	1108	Foot Bridge
15.	1197	Pipe crossing
16.	1414	Drop cum pipe culvert
17.	1437	Tail dam

Sd/-
Executive Engineer,PWD
V.R.P. Division, Harur.



REFERENCE

RIVER		NEW DRY AYACUT
ROADS		
CANALS		
RAILWAY LINE		
CATCHMENT AREA		
WATER SPREAD AREA		
PROPOSED RESERVOIR SITE		
RAINFALL STATION		

GOVERNMENT OF TAMILNADU
PUBLIC WORKS DEPARTMENT

VANIAR RESERVOIR SCHEME
INDEX MAP

SCALE 1" - 4 MILES

Sd/- - - - - - -
For Chief Engineer (INV)

FIG-4.2.6

INDIA - TAMIL NADU			
UNDP / UNDTCD PROJECT IND/82/058			
STRENGTHENING THE INSTITUTE FOR WATER STUDIES			
CATCHMENT MAP OF VANIAR AND KOTTAPATTI KALLAR SUB-BASIN			
I.W.S. DRG NO:	CHECKED BY	C. RAGHAVENDRA RAO	Dr. VLADIMIR BAKLEY
PREPARED BY	TRACED BY		

பதிப்பாசிரியா
விவரச்சுவடி
15 ...
எழும்பூர், சென்னை-600 008

தமிழ்நாடு ஆவணக் காப்பகம்
227981
சென்னை-600 008
நூலகம்

7.2116.V
N99